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SUMMARY REPORT ON WATER POLLUTION, SOUTHWEST-LOWER MISSISSIPPI DRAINAGE BASINS

Public Health Service
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For Clean Water—"One River, One Plan"

Summary Report

Southwest-Lower Mississippi
DRAINAGE BASINS

A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

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SUMMARY REPORT ON WATER POLLUTION

Southwest-Lower Mississippi Drainage Basins

Prepared by

FEDERAL SECURITY AGENCY
Public Health Service
Division of Water Pollution Control
Southwest-Lower Mississippi Drainage Basins Office

1951

In cooperation with:

Arkansas Water Pollution Control Commission
Colorado Department of Public Health
Kansas State Board of Health
Kentucky Water Pollution Control Commission
Louisiana Stream Control Commission
Mississippi State Board of Health
The Division of Health of Missouri
New Mexico Department of Public Health
Oklahoma State Department of Health
Tennessee Stream Pollution Control Board
Texas State Department of Health

I

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II

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INTRODUCTION

The Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June of 1948, requires the Surgeon General of the Public Health Service to cooperate with other Federal agencies, with State and interstate water pollution control agencies, and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters.

In developing these programs, due regard must be given to improvements necessary to conserve the Nation's waters for public water supplies, propagation of fish and aquatic life, recreational purposes, agricultural, industrial, and other legitimate uses.

Recognizing the fact that full technical information was not available to permit the development of such comprehensive programs immediately for most of the Nation's waters, the Public Health Service envisioned the development of these programs in two general phases. The first phase contemplated the development of a series of reports, consistent with presently available data, which would: provide a reference point for measuring progress; provide a guide to needed additional data; provide a basis for the logical development of comprehensive programs; provide a basis for approval of loans to States, interstate agencies and municipalities at such time as the Congress made available funds for this purpose; and serve to inform the public on the problem of water pollution and set forth suggestions for pollution control.

The collection of available data as of July 1, 1950, has been completed under the first phase of the program. Such data have been assembled with the cooperation of State and interstate water pollution control agencies. Through these agencies additional data have been obtained from other State officials, county and city officials and representatives of industry. Federal agencies also have been of great assistance. In order to make this information available at the earliest possible moment, these data are being presented in 15 summary-type reports covering the United States by major drainage basins. This report on the Southwest-Lower Mississippi Basins is one of that series.

These summary reports present information about the ways our water resources are used, the pollution going into our water resources and the resulting damages, the benefits which may result from pollution prevention and abatement, the pollution prevention measures now in effect, and those required.

They are prepared in two parts. Part one considers the water pollution problems of the basin as a whole. Part two presents briefly the data for each of the several sub-basins of the major basin, including a list of projects now known to be needed for water pollution control.

Since the summary reports are based on data which are now readily available, these reports do not discuss or evaluate the most advantageous water uses as they are related to pollution control. Such considerations will be included as a part of the comprehensive water pollution control programs.

The deficiencies in data and the gaps in information indicated in these summary reports are as significant as the presentation of available facts and statistics. They indicate the work which still needs to be accomplished by water pollution control authorities for the preparation of comprehensive programs.

Data and knowledge now available are sufficient, however, to permit the immediate solution of many of the pollution problems within the Southwest-Lower Mississippi Basins without awaiting the results of additional surveys and studies. The tabulations of pollution abatement projects which are included in Part Two of this summary report represent presently known needs. However, future studies and evaluations may result in some changes in the estimations of requirements.

A sincere effort has been made by all who contributed to this report to present a fair picture of the complex water pollution problems in the Southwest-Lower Mississippi Basins and to present reasonable conclusions and recommendations. It is our hope that this report, as a step in the cooperative development of an ultimate comprehensive pollution control program, will help in safeguarding the water resources of the Southwest-Lower Mississippi Basins.

Leonard A. Scheele

Surgeon General

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Arkansas Water Pollution Control Commission
Colorado Department of Public Health
Kansas State Board of Health
Kentucky Water Pollution Control Commission
Louisiana Stream Control Commission
Mississippi State Board of Health
The Division of Health of Missouri
New Mexico Department of Public Health
Oklahoma State Department of Health
Tennessee Stream Pollution Control Board
Texas State Department of Health

Federal agencies from whose reports extensive data were obtained include: Department of Agriculture; Corps of Engineers, Department of the Army; Bureau of the Census, Department of Commerce; Bureau of Mines, Bureau of Reclamation, Fish and Wildlife Service, Geological Survey, and National Park Service, Department of the Interior.

SUMMARY

The Southwest-Lower Mississippi Drainage Basins include the area drained by the entire Arkansas, White, and Red Rivers together with the local area drained by the lower reach of the Mississippi River, extending from Cairo, Ill. to the Gulf of Mexico. The basins embrace all of the States of Oklahoma, Arkansas, most of Louisiana and portions of Colorado, New Mexico, Texas, Kansas, Missouri, Kentucky, Tennessee, and Mississippi; they are almost 900 miles long and average about 400 miles in width and comprise a total area of nearly 340,000 square miles.

The topography developing from the west, is rugged through the headwaters regions in Colorado and New Mexico and changes abruptly to the undulating terrain of the Great Plains eastward to central Kansas and Oklahoma. The Plains region merges into the rolling prairies and broken hills lying in eastern Kansas and Oklahoma. East and south of Little Rock, Ark., the topography blends into the flat alluvial valley of the lower Mississippi River. The area is prominently marked by the Boston and Ozark Mountains in eastern Oklahoma and western Arkansas and by the Ouachita Mountains in northwestern Arkansas.

The climate varies from arid and semiarid in the western regions to mild and damp in the central and eastern portions. The southeastern portion, including the State of Louisiana, experiences long periods of humid climate. Rainfall associated with the climatic regions ranges from less than 20 inches in the west and increases gradually to 45 inches annually eastward to northeastern Arkansas. The rainfall in southern Arkansas and northern Louisiana averages 50 inches annually and averages of 60 inches are not uncommon in southern Louisiana.

Moderate stream flows in the headwaters of the Arkansas River originating from light rainfall and melting snows are diminished in the semiarid region of eastern Colorado and western Kansas by evaporation, channel absorption, and diversion for irrigation. Alternate extremes of drought and excessive rainfall are comparatively frequent in the central portion of the region. Runoff in the eastern area varies generally as the rainfall and the stream flows are large and erratic. Flood control is a problem along the Mississippi River and immediate tributaries.

The estimated 1950 population of the basins is approximately 11,500,000. The largest population centers are found in the east central region extending from Oklahoma City, Okla. to Memphis, Tenn., and in Louisiana. There are over 30 major cities in the area with populations ranging from 15,000 to 600,000, including New Orleans, with a population of 567,257.

The region is rich in natural resources, the most important of which are petroleum, natural gas, metallic and non-metallic ores, fertile soils, timber, and water. A large part of the vast mid-continent oil field is located in the central portion of the basins. Nearly 95 percent of the bauxite ore produced in the United States is mined in central Arkansas and commercial quantities of timber are found throughout the eastern region.

Agriculture, including livestock raising, is one of the most important economic activities in the basins. Wheat, cotton, corn, forage, soy beans, and sugar beets are the important crops produced in the central region. Cultivation of truck crops is important in the irrigated areas of the western portion and rice culture is practiced extensively in the Grand Prairie Region of Arkansas and also in southwestern Louisiana.

The production and refining of petroleum is one of the most important industrial activities in the region. Other major industries associated with the products of the area, including natural gas production, paper mills, and food processing plants, are also represented in fair share.

The basins are endowed with an abundance of fish and wildlife resources which offer great recreational opportunities to the inhabitants. Game fishing is found in the White River Basin and streams of the eastern portion of the basins, while commercial fishing, shellfish production and muskrat trapping are of greater economic importance in the Gulf waters and marginal coastal areas.

Surface and underground water resources are of equal importance and are utilized extensively throughout the area for the following purposes: public and industrial water supplies; agricultural use; recreation, including fishing, hunting, bathing, and other activities; commercial fishing; and power development and navigation.

Surface waters mainly are used for sources of public and industrial supplies in the central portion of the region. In the eastern and western regions, however, underground waters are utilized to a greater extent for public supplies. Throughout the entire area there are over four times as many communities utilizing underground waters for public supplies as compared to the number using surface sources, but on the basis of population served and rate of consumption, the use of surface and underground waters is of equal importance. There are 269 communities utilizing surface water supplies to serve 2,633,000 persons with an average of 327 million gallons daily and 1,136 communities using underground sources of water supply to serve 2,825,000 persons with an average of 289.5 million gallons daily. Data regarding the industrial water use are available only for a few specific areas and therefore are considered inadequate to apply to the total use for this purpose in the entire area.

The use of both surface and underground waters for agricultural purposes, including irrigation, and livestock watering, is one of the more important water uses in the basins. Extensive irrigated areas in excess of one-half million acres have been developed in the semiarid regions of the upper Arkansas and Red Rivers for the cultivation of truck crops. In the Grand Prairie Region of Arkansas about 450,000 acres are irrigated largely from underground sources of waters for the culture of rice exclusively. Equally extensive rice growing areas located in southwestern Louisiana are irrigated mainly by surface waters and supplemented by water from underground sources.

Limited water supply in the western areas and in the Grand Prairie Region of Arkansas has restricted the development of irrigation projects. Conservation of the available water and supplementing the supply from other areas is considered essential for the development of irrigation projects in these areas. Pollution control is necessary to protect the abundant surface waters used for the irrigation of rice in southwestern Louisiana.

Fishing and hunting opportunities which enjoy national reputation are the principal recreational uses of the waters in the basins. It has been estimated that in 1949, probably about 300 million dollars were spent in the basins for licenses, equipment and travel in pursuit of this sport. Bathing is of local importance but development of this use near centers of population has been hampered by pollution. Boating is popular on the navigable streams and large impoundments in the eastern half of the area. Numerous parks and wildlife refuges have been developed for the conservation of fish and wildlife resources. Many of these restricted areas in the picturesque mountainous regions are attractive for camping and picnicking.

Many streams in the area are used for commercial fishing. The yield from the inland streams, however, comprises only a small part of the total production and value of this important activity as compared to the large production of shellfish, shrimp and other fishes taken from the Gulf and marginal coastal waters.

Many rivers in the region offer potentials for the development of power projects. There are seven projects in operation or under construction which have a total installed capacity of 465,000 kilowatts and in addition have provisions for about nine million acre-feet of flood control storage.

Navigation is of major importance on the Mississippi River which traverses the eastern portion of the area for a distance of 600 miles from Cairo, Ill., to the Gulf. Several of the rivers in Louisiana are navigable for ocean-going vessels for considerable distances from the Gulf. Navigation on the Arkansas, White, and Red Rivers, however, is limited to the lower reaches of these rivers and to the transportation of local products.

A summary of data on the number of municipal sources of pollution shows that there are 821 sewered communities within the area, with a combined population of nearly five million. An estimate of the amount of pollution originating from the municipal sources, including domestic sewage and industrial wastes discharged to city sewers, is available, however, for only 69 percent of the sewered communities. The pollution load from 564 municipalities, for which estimates are available, has a population equivalent of about 1,900,000. The amount of pollution contributed by the remaining 257 municipalities is undetermined.

Similar data show that there are 1,081 sources of industrial pollution reported as discharging wastes directly to the watercourses. The estimated pollution load contributed by 32 known sources producing organic wastes is equivalent, on an organic load basis, to the domestic wastes from a population of about 1,360,000. The amount of pollution originating from the remaining sources, producing organic and inorganic type wastes, is undetermined or unknown.

Pollution from industries producing inorganic wastes is one of the major problems in the basins. The disposal of oil well brines and waste oils resulting from oil production and processing operations has been an important factor contributing to the degradation of the water resources. The extensive nature of these operations, resulting in large volumes of wastes, and the difficult problems of disposal have resulted in considerable pollution of both surface and underground waters. Silt pollution resulting from soil erosion and mineralization of waters brought in contact with natural salt and gypsum deposits also merits important consideration in this area.

Damages resulting from pollution have affected nearly all important water uses to some degree, either directly or indirectly. Specific damages to the water resources have resulted in most part from oil well brines and municipal wastes. Instances of damages to water supplies, agriculture, fish and wildlife, and recreation are common in the basins.

Intangible losses resulting from restricted economic developments and possible detrimental effects to public health are of equal importance in the consideration of these damages.

Specific benefits resulting from pollution control are largely of a local nature, but the general benefits can be readily applied to all legitimate water uses. High costs for the treatment of polluted waters for public and industrial supplies can be decreased and large capital outlays for expansion of facilities to maintain capacity, or for the development of new sources, can be avoided. Loss of livestock exposed to polluted water will be reduced. Pollution of waters utilized for agricultural purposes has restricted agricultural developments and reduced crop yields. However, abatement of pollution will greatly reduce these losses. The conservation and propagation of important fish and wildlife resources will benefit from the restoration of many polluted streams and recreational activities can be developed near centers of population for the convenience of many. The control of silt pollution also can be expected to reduce treatment costs of water supplies and to restore production of fish and other aquatic life through the protection of spawning beds and food supplies. In addition to conserving the valuable soils for agriculture, sediment control prolongs the useful life of all impoundments, especially power development projects, and facilitates development and maintenance of aid-to-navigation projects.

Gradual progress in pollution control is evident throughout the basins in general. The control measures in many local areas, however, have not been adequate to keep pace with the increased pollution and progressive deterioration of watercourses has resulted. This condition is particularly evident throughout the central zone of the area where the larger centers of population are concentrated, and in some areas of the eastern and southeastern portions where considerable industrial activities are located. Pollution prevention measures in effect consist of: exercising of State legislative authority, promoting the construction of pollution abatement facilities, and conducting educational programs related to the various aspects of pollution prevention and abatement.

The Arkansas-White-Red Basins Inter-Agency Committee, with membership representing all Federal departments having interests in the land and water resources of the three river basins, has been directed by the President to study the aspects of and formulate a comprehensive and integrated plan for the conservation and development of these resources. The activities of the Committee are supported by active participation of the various State agencies, group organizations, and individuals. Consideration of plans and proposals by this group is promoting unified action among the many Federal and State agencies, and others having interest in water pollution problems. The findings and recommendations of the Committee are anticipated with keen interest by all concerned with the prevention and abatement of pollution in the area.

Data available regarding existing municipal waste treatment plants show that some type of treatment is provided by 640, or 78 percent, of the 821 municipalities having sewerage systems. The population served by treatment facilities is about 2,800,000, or 56 percent, of the total sewered population of nearly 5,000,000 within the area. Similar data show that of the 1,081 industries discharging wastes directly to watercourses, only 68 are known to have some type of waste treatment facilities, 144 are reported as having no treatment facilities, and the status of treatment facilities for 869 industries is undetermined.

The effectiveness of the existing municipal waste treatment plants in the abatement of pollution is partially discounted by the fact that about 60 percent of these plants are inadequate for reasons of capacity, due to population growths or other factors contributing to overloading, and about 50 percent are subjected to poor operation. Table 1 presents a summary of municipal waste treatment plant data for the region developed from data for each of the 21 sub-basins.

The pollution prevention measures required within the basins are generally recognized. Pollution control has been handicapped to some extent, in some areas of the basins, however, by inadequate legislative authority, by the exercise of responsibility by several agencies within a single State, and by restricted program activities resulting from an inadequate number of personnel and limited funds.

Available data show that 517 municipal waste treatment projects including requirements for 132 new plants, enlargements or additions for 251 plants, and replacement of 134 existing plants are known to be needed to adequately treat municipal wastes. These projects involve nearly 3,000,000 persons or about 60 percent of the total sewered population in the area. No projects are needed in 289 municipalities, and the requirements for 40 municipalities are undetermined. Specific industrial waste treatment requirements include 43 new plants and 21 improvement projects. The requirements for 979 industries, however, are as yet undetermined.

During World War II, activities in the field of pollution abatement suffered considerable setback due to necessity for diverting material to the war effort. Since the war, however, some increased rate of construction of waste treatment plants is noted within the

Table 1. Summary of municipal waste treatment plant data

Sub-basin (1)	Sources of pollution (In number of municipalities) (2)	Population served by sewer systems (3)	Municipalities with treatment plants			Plants with adequate capacity		Plants with adequate operation	
			Total number (4)	Population served (5)	Percent of total sewered population (6)	Number (7)	Percent of total (8)	Number (9)	Percent of total (10)
Upper Arkansas River (Above Kansas-Colorado State Line)	38	171,800	18	123,900	72	8	47	5	29
Arkansas River (Kansas-Colorado State Line to Tulsa)	94	421,800	68	344,300	82	40	59	38	56
Verdigris River	28	126,000	26	121,200	96	8	31	12	44
Grand (Neosho) River	49	194,800	40	167,500	86	20	50	26	62
White River	38	132,700	31	111,300	84	12	38	12	38
Lower Mississippi River (Cairo, Ill. to Helena, Ark.)	73	529,400	49	123,800	23	17	33	38	73
Cimarron River (N. Mex., Colo., Kans., and Okla.)	33	92,000	31	78,500	85	18	58	18	58
North Canadian River	52	449,700	48	420,200	93	16	33	33	67
Arkansas River (Tulsa, Okla. to Van Buren, Ark.)	31	236,200	22	34,300	15	11	48	13	57
Arkansas River (Van Buren, Ark. to Mouth)	23	189,800	16	38,500	20	3	18	2	12
Lower Mississippi River (Yazoo River)	42	127,100	24	38,300	30	16	67	16	67
South Canadian River (Above Texas-Oklahoma State Line)	16	101,800	15	94,800	95	7	47	8	53
South Canadian River (Below Texas-Oklahoma State Line)	23	66,700	22	63,800	96	11	48	19	82
Washita River	30	62,400	25	49,300	79	2	8	5	20
Upper Red River (Above Denison)	71	272,300	66	254,900	94	24	35	28	41
Lower Red River (Below Denison)	67	515,100	57	305,700	59	23	38	18	30
Ouachita River	46	207,700	36	129,300	62	7	17	6	15
Lower Mississippi R. (Big Black River)	15	23,400	10	10,400	45	2	20	4	40
Atchafalaya River	16	106,900	12	92,100	86	8	67	9	75
Calcasieu River	6	70,900	5	63,900	90	5	83	5	83
Lower Mississippi River (Natchez, Miss. to Gulf)	30	862,700	19	109,900	13	12	60	9	45
Southwest-Lower Mississippi Drainage Basins (total)	821	4,961,200	640	2,775,900	56	270	42	324	49

area. A total of 48 municipal plants, designed to serve a population of 229,200 were built during the five-year period 1946-1950. Eight industrial waste treatment plants were reported as having been constructed during the same period.

The present status of needed treatment works projects indicates slow action toward pollution abatement. Of some 554 projects considered necessary, only 86 are under active consideration, no formal action has been taken on 149 and the status of 319 projects is undetermined. The project needs for nearly 1,000 sources of industrial pollution are reported as undetermined.

Although pollution control within the basins is not a recent activity, inadequate legislation, resulting from the adoption of piecemeal laws, has contributed in no small part to the slow progress in pollution control in some States in the basins. Several of the States have come to realize the limitations of this type of legislation. Recently, Arkansas adopted comprehensive water pollution control legislation. Colorado and Oklahoma are presently in the process of developing similar legislation. Tennessee, in 1949 and 1950, was operating under restricted enforcement provisions of its existing pollution control laws. Kansas and Texas are operating under statutes which are considered adequate by these States.

The underlying concept and purpose of uniform water pollution control legislation is to facilitate interstate cooperation and the development of mutually complimentary programs for water pollution control. The use of interstate compacts or agreements as a means of solving common problems extending beyond borders of jurisdiction has been on a limited and restricted basis by the States in the basins. One interstate compact is in effect within the basins and two others are in the process of negotiation between the States. All of these compacts deal primarily with the apportionment of the water of the Upper Arkansas River, Canadian River, and Red River, respectively.

From the data available, it is estimated that the initial cost for providing the needed municipal waste treatment facilities in the basins will be approximately $50,000,000. This estimate takes into consideration the projects required to treat municipal sewage and industrial wastes discharged to city sewers. The lack of adequate data regarding the sources and amounts of industrial wastes and the complexities involved in determining the type and magnitude of waste treatment facilities for the various kinds of industries discharging directly to the watercourses precludes an estimate of cost for needed industrial wastes treatment facilities in the basins.

CONCLUSIONS

1. The climatic and physical conditions found throughout the basins emphasize the importance of the conservation of the water resources for the development of the basins' economy. Pollution control for the protection and restoration of the water resources to permit optimum utilization of the waters is recognized as an integral part of water conservation measures.

2. By virtue of the large undeveloped areas in the basins, pollution is not considered widespread. Localized conditions of gross pollution, however, are common throughout the east-central portion of the basins. The local pollution problems originate mainly from the discharge of wastes from the production and refining of petroleum and from municipal wastes.

Natural pollution in the form of sediment and dissolved minerals is a major problem throughout much of the basins. With some exceptions, all streams in the western portion of the basins are laden with silt, and the waters are mineralized to a greater or lesser degree from contact with natural salt and gypsum deposits.

3. Specific damages resulting from pollution have affected in varying degree all important water uses. The more important uses so affected include: public and industrial water supplies, agriculture, recreation, and propagation of fish and other aquatic life.

4. The benefits which result from a program of pollution control can be related directly to specific pollution damages suffered in the basins and indirectly to potential hazards to public health and to restricted economic and recreational activities for which the areas are otherwise suited.

5. Although pollution control measures are being carried on, the application of these measures in many areas has lagged behind encroaching pollution. The lack of concerted action through some State agencies, inadequate legislative authority, limited technical staffs, and insufficient funds for the administration of an aggressive pollution control program are several factors responsible for the present day conditions of the water resources in some areas of the basins.

6. Inadequate legislation in some States has resulted in most part from the enactment of fragmentary statutes applying to limited or specific pollution problems. Administration of a broad pollution control program is handicapped by the application of limited and inconsistent legislation developed through such procedures. The need is apparent in all but few of the States within the basins for more adequate legislation, broad in the definition of water pollution, and uniform in basic principles considered desirable for good and adequate legislation. Uniformity of water pollution legislation among the several States will aid the States in their own work and facilitate cooperation in the solution of pollution problems interstate in scope. The use of interstate compacts and agreements has been on a limited and restricted basis among the States in these basins. The value of this device should be recognized and utilized to a greater extent as a means of accomplishing pollution control on the logical river basin approach.

In some areas, however, considerable improvement of pollution problems has been made by informal cooperation.

7. Pollution control in the basins has also been handicapped by the lack of technical knowledge, especially as related to the treatment of several industrial wastes. The development of oil well brine disposal methods, which has contributed greatly toward the abatement of pollution from this source, is relatively new and resulted from the cooperative investigation and research efforts of governmental agencies and industry. An accelerated program of research designed to cover the broad field of waste treatment, especially industrial waste treatment, is essential for the continued development of effective pollution control programs.

8. Delayed administrative action and postponed construction of treatment works has taken its toll of the water resources. It has also created a considerable backlog of needed facilities and a need for large financial expenditures to restore and protect the waters for present and future use. It is estimated that the initial cost of needed municipal waste treatment plants for the entire area will be approximately $50,000,000. This estimate is based on available data and it is reasonable to assume that a re-estimate of cost, when more complete data become available, will increase this figure appreciably.

9. In some States, existing municipal tax structures and financing methods have hampered water pollution abatement efforts. An examination of financing methods, including those relating to industrial waste treatment facilities, is indicated in order to determine the needed improvements in those methods.

10. Accomplishing initial construction of needed waste treatment plants should not be considered the end point for pollution control objectives. Present conditions indicate that

about 60 percent of the existing plants are inadequate with relation to capacity and about 50 percent are subjected to poor operation. These data show that plant expansions and improvements have not kept pace with population and community growth and also underline the need for better plant operation control.

11. Data available from the several States in the basins contain wide gaps and are generally inadequate for the purposes of determining completely the scope of the pollution problems. The lack of information, especially regarding sources of industrial pollution, similarly precludes a complete evaluation of the requirements for corrective measures for pollution prevention and abatement. Supplemental data regarding sources and amounts of pollution, desirable water uses, water quality requirements, and needed corrective actions are considered a prerequisite to the development of a comprehensive program for water pollution control within the basins.

12. The establishment of the Arkansas-White-Red Basins Inter-Agency Committee, to study the land and water resources within the three river basins, represents a milestone in integrating pollution control with the coordinated inter-agency effort applied to basin-wide problems. Integrated viewpoints representing the interests of the various Federal and State agencies concerned with water resources problems must be considered in carrying out a sound program of pollution prevention and abatement.

RECOMMENDATIONS

It is recommended that:

1. Although data available are generally incomplete, they are sufficient in regard to water pollution problems to permit instituting sound corrective measures in many local areas. In these areas the States, in cooperation with the local governmental and industrial authorities, should establish requirements or intensify corrective measures and promote and expedite construction of treatment works or other pollution preventive measures which will be in accord with future comprehensive river basin development.

2. Continued and accelerated efforts should be made by the responsible water pollution control agencies of the several States to secure supplemental data, particularly on industrial waste pollution, for the purpose of more adequately defining the pollution problems, and to permit development and administration of comprehensive programs of sound corrective measures.

For this purpose, efforts should be directed toward:

(a) Locating all sources of municipal and industrial wastes and determining the characteristics and amounts of wastes discharged to the watercourses.

(b) Determining the polluting effect of the wastes and evaluating the damages to the watercourses.

(c) Determining desirable water quality objectives for present and future primary water uses.

(d) Establishing and administering regulations for minimum requirements for waste treatment and disposal.

(e) Promoting the construction of needed waste prevention and treatment facilities.

(f) Maintaining and improving operation of waste treatment plants and fostering educational programs for training of plant operators.

(g) Examining municipal tax structures and financing methods as applied to sewage and industrial waste treatment works to determine needed improvements.

3. In those States now handicapped by enactment of piecemeal and inadequate legislation for the administration of water pollution control, the primary effort should be directed toward the amendment and supplementing of existing statutes with the purpose in view of developing uniform comprehensive water pollution control legislation.

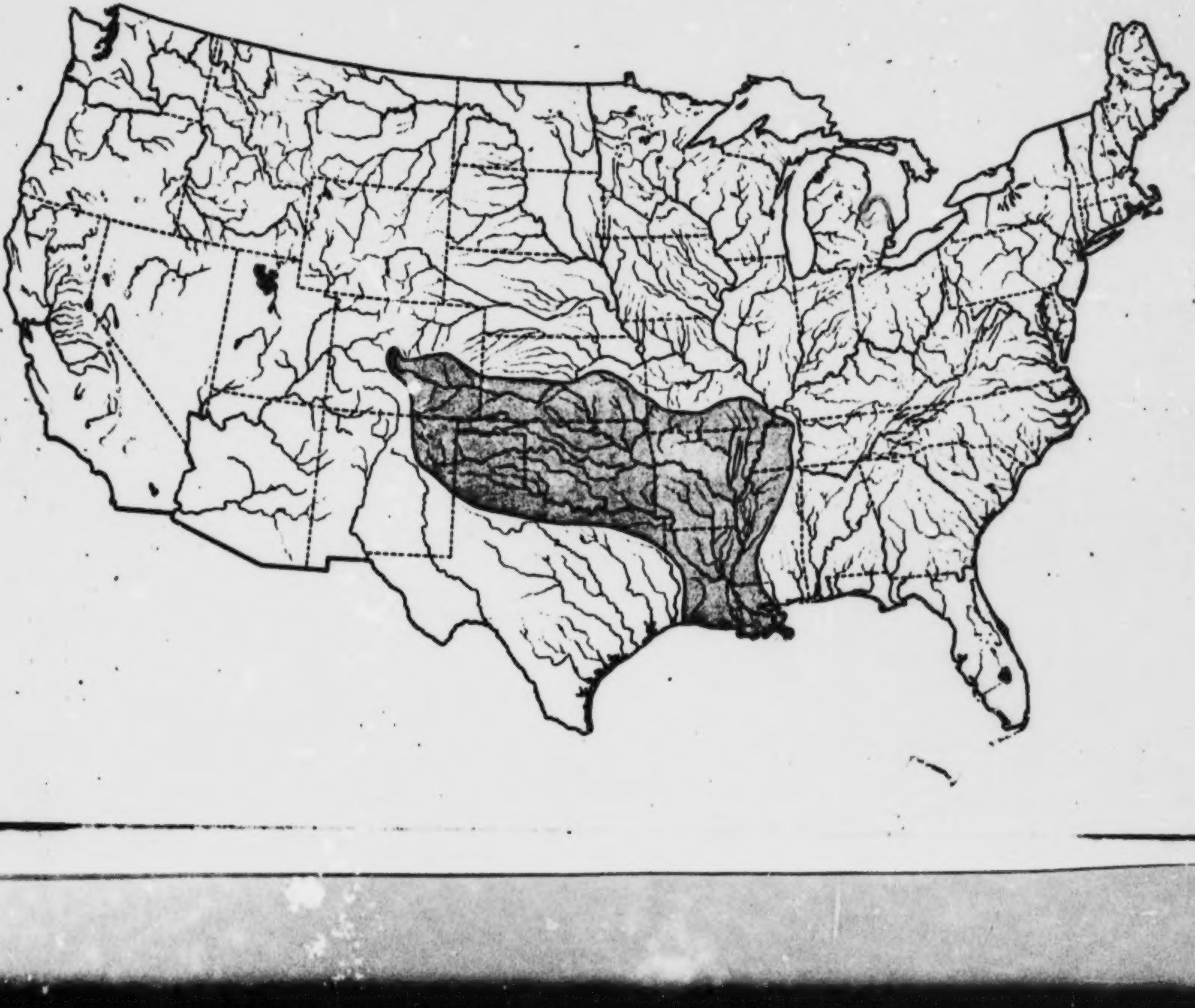
4. The underlying concept and purpose of uniform legislation is to facilitate interstate cooperation and the development of mutually complimentary programs for water pollution control. The use of interstate agreements and compacts has been on a limited and restricted basis within the basins. The value of such agreements and compacts should be recognized and utilized to a greater extent by the several States within the basins as a means of controlling interstate pollution.

5. For those State water pollution control agencies now handicapped by lack of State appropriations or insufficient funds, the State legislatures should provide adequate funds commensurate with the delegated responsibilities and duties of those agencies.

6. Active and continued participation be maintained by the State water pollution control agencies in the program of the Arkansas-White-Red Basins Inter-Agency Committee. Such participation should include consideration of all pollution problems related to the various aspects of water resources conservation and development.

LOCATION MAP

Southwest-Lower Mississippi Drainage Basins



GENERAL DESCRIPTION

Historical Background

The Southwest-Lower Mississippi Drainage Basins area contains some of the Nation's largest inland waterways. The largest--the Mississippi River--traverses the entire eastern portion of the region for a distance of about 600 miles. The Arkansas River courses the full east-west expanse of the area, and is surpassed in size by only the Mississippi and Missouri Rivers.

Earliest exploration dates back to 1519 by Alvorez de Pirreda, in the region of the mouth of the Mississippi. Explorations in the northern area of the basins date back to 1541, when DeSoto made the first trip up part of the Arkansas River. He was followed in 1682 by La Salle, who toured down the Mississippi River and claimed the land for France.

In 1783 the United States gained possession of the east banks of the Mississippi River down to the 31st parallel. This was followed by the Louisiana Purchase in 1803, which gave the United States control of the entire Mississippi Valley and practically the entire area included in the Southwest-Lower Mississippi Drainage Basins.

The city of New Orleans was established in 1718 and Louisiana became a State in 1812.

DeSoto (1541) was the first European to explore the region now known as Arkansas. This area became part of the United States as a result of the Louisiana Purchase, and was admitted to the Union in 1836.

The territory of Oklahoma was established through the Homestead Act of 1889 and became a State in 1907.

The Kansas portion of the area gained prominence through the 400-mile long Santa Fe Trail established in 1824. This passageway--part of the 1842 trail blazed by Fremont--was the first overland route to California, Oregon and Mexico.

The Kansas-Nebraska Act admitted Kansas as an organized territory in 1854, and was followed by her admission to the Union in 1861.

The Gold Rush of 1849 opened up the Colorado portion of the area to extensive settlement.

As railroads and telegraph lines stretched across the vast wilderness, settlers surged beyond the continental barrier of the Mississippi and established homes and cities. The great plains were fenced for general and specialized farming, and industrial development soon followed.

Physical Description

The area of the Southwest-Lower Mississippi Drainage Basins includes the large Arkansas, White, Red and Lower Mississippi Rivers drainage basins, and several smaller river basins in the east and southeastern regions.

This comprises about 340,000 square miles. The total area includes the Arkansas River Basin with 160,375 square miles, or 47 percent; the White River Basin with 27,765 square miles or about eight percent; and the Red River Basin with 66,108 square miles or about 20 percent of the total area. In addition, approximately 85,000 square miles are included in the minor basins of the Calcasieu, Atchafalaya, Yazoo and Black Rivers in Louisiana and Mississippi.

The basins are almost 900 miles long and average approximately 400 miles in width. They begin in the Rocky Mountains of Colorado and extend in a southeasterly direction to the Lower Mississippi River and include small sections of Colorado, New Mexico, Texas and Missouri, Kentucky, Tennessee and Mississippi; large portions of Kansas and Louisiana and all of Oklahoma and Arkansas.

The topography of the Arkansas River Basin is mountainous west of Canon City, Colo., and is rugged through the foothills eastward to Pueblo, where it changes abruptly to the undulating terrain of the Great Plains. The Plains region extends east to Hutchinson, Kans., to merge into an area of rolling prairies and broken hills lying in Eastern Kansas and Oklahoma. The basin is prominently marked in Eastern Oklahoma and Western Arkansas by the Ozark Mountains and the Boston Mountains on the north, and by the Ouachita Mountains on the south. Near Little Rock, Ark., the topography blends into the flat alluvial valley of the lower Mississippi River.

The White River Basin embraces most of the Boston and Ozark Mountain region which blends into the rolling foothills of the eastern portion of the major basins.

The headwaters area of the Red River Basin is semiarid in character and the river rises from a network of small streams. The main channel through western Oklahoma is poorly defined and is continually shifting in the sandy waste lands. East of the "bad lands" lie the rolling plains section of Texas and Oklahoma.

The rugged Wichita Mountains form the northern divide.

Through eastern Oklahoma and Texas, the river plain is broad and well suited to farming. As the stream approaches Louisiana the country becomes a rolling plain, heavily wooded with pines in the uplands and hardwoods in the bottoms. The "backwater" region below Alexandria drains considerable timbered swamp lands. There is little cultivation in this area and inundation during high water is not uncommon. The Ouachita River forms a part of this drainage area from Arkansas and includes a portion of the Ouachita Mountains and flat swampy lowlands.

The average annual temperatures in the area range from 44°F. at high altitudes in the western regions to 65°F. in the eastern lowlands and marsh areas. Excessive hot or drought periods are occasionally experienced outside the mountainous areas. The climate is mild and dry in the western and central portions and often accompanied by steady winds of rather high velocity. The southwestern area has a semi-arid to moderate climate, while the eastern and southeastern portions range from mild to extremely humid climates.

Rainfall decreases from about 25 inches annually in the Rocky Mountains area to 12.5 inches near Las Animas, Colo. Extending eastward it increases gradually to about 40 inches on the southern slope of the Boston Mountains in Northeastern Arkansas, and averages of 60 inches are not uncommon in Louisiana.

Runoff varies widely due to differences in climate, vegetation, soil and topography. However, moderate stream flows from the Rocky Mountain section are greatly diminished in the semiarid region of eastern Colorado and western Kansas by evaporation, channel absorption, and diversion for irrigation. Almost all of the flow of the Arkansas River in Oklahoma and Arkansas originates in that part of the area east of the 98th meridian as a result of rainfall and spring runoff due to melting snows.

Alternate extremes of drought and excessive rainfall are comparatively frequent in the central regions of the major basins. Runoff varies generally, as does the rainfall in the southwestern region of the basins, and therefore flows are erratic and even intermittent in this section.

Stream flows in the eastern reaches of the area are rather low in summer and fall because of less runoff and high evaporation and transpiration on the watershed during this period.

Economic Development

The 1950 population of the basins is approximately 11,500,000. The greatest population concentrations occur in east central Oklahoma, extending from Oklahoma City to west central Arkansas including Little Rock. There are over 30 major cities in the basins with populations ranging from 15,000 to 600,000, including New Orleans, La. with a population of 567,257.

The area is rich in natural resources, the most important of which are minerals, fertile soils, and timber. The principal mineral resources are petroleum, natural gas, lead, zinc, coal, manganese, and bauxite. A large part of the vast mid-continent oil field is within the central portion of the basins, and 94 percent of the bauxite ore produced in this country, is mined in central Arkansas. Most of the commercial quantities of timber are found throughout the eastern portion of the major basins area.

Some of the more important industries are oil and gas production and oil refining; lumber manufacturing and related products; also mining and quarrying. Lime and cement are manufactured extensively in several sections of the basins, principally in the White River Basin.

Wheat, cotton, corn, forage, soy beans and sugar beets are important agricultural products in the central and eastern portions of the major basins.

Truck gardening and rice growing are carried on especially in the extreme eastern and southeastern sections. Many canneries also are found in the east central regions along with large fruit farms. Extensive stock raising is practiced in the western regions; while some stock raising and a great deal of dairying also is carried on in the eastern portions. Truck farming is important in the far western reaches of the area where vast irrigation systems have been established.

There are many recreational areas in the form of national and State parks and wildlife refuge areas. Most of these are located in the central and eastern basin regions, and in the Louisiana district. There are many fish hatcheries scattered throughout the area.

Game fishing is an important recreational activity in the east central area of the basins, while commercial fishing, the shellfish industry, and the fur industry, such as muskrat trapping and farming, is quite widespread in the Gulf waters and marginal coastal area.

USES OF WATER RESOURCES

Surface and underground water resources are of equal importance and are utilized extensively throughout the major basins. The uses of the water resources are as varied as the different geographic and climatic conditions and the many diversified economic activities found across the basins. The important water uses which are considered pertinent to the subject of water pollution control in these basins and discussed herein are the following: public and industrial water supplies; agricultural use, including irrigation and livestock watering; recreation, including fishing, hunting, bathing and other activities; commercial fishing; power development; and navigation.

Throughout the arid and semiarid areas of the western third of the basins, extending from the Rockies to the 98th meridian, the available waters are used mainly for agricultural purposes. In the central basins area, which supports the main centers of population and industrial activity, the water resources are used mainly for public and industrial water supplies. Other uses of the waters in this area include game fishing, some commercial fishing, and power production.

The eastern portion of the basins, which includes the White River Basin, the area draining to the main stem of the Mississippi River, and the Gulf Coast area, is considered unique with respect to adequacy of the water resources and uses of the waters as compared to the central and western portions of the basins. Although surface water is abundant, the majority of the smaller communities utilize underground waters for sources of public supplies. Extensive areas in the White River Basin are devoted to wildlife refuges, while the surface waters are popular for recreational activities and especially for hunting and game fishing. Two large flood control and power development projects are located in the White River Basin. In the Grand Prairie region and in the vicinity of Jonesboro and McGehee, Ark., extensive acreage is irrigated for rice culture primarily from groundwater sources. Water used for irrigation of the large rice fields in western Louisiana is diverted from the many surface sources in the area and is supplemented by withdrawal from ground-water sources. Industry also utilizes considerable surface water in this area. The Gulf waters and many of the streams tributary to the Gulf are used for large scale commercial fishing operations and are productive of shellfish and shrimp. Wildlife refuges and muskrat trapping areas are found throughout the marsh waters bordering the Gulf coast.

Navigation is one of the important uses of the streams in the eastern portion of the basins. The Mississippi River is the principal waterway in the basins. Other rivers leading to the Gulf are navigable for deep draft vessels many miles from the coast. The lower reaches of the Arkansas and Red rivers are used to some extent for local water transportation.

The use of surface waters for the disposal of municipal and industrial wastes has been and is being exploited throughout the major basins. In many instances the uncontrolled disposal of these wastes has continued at the expense of more important primary uses. It is recognized that a certain portion of the surface waters should be allocated for the ultimate disposal of wastes, however, this use is considered of lowest priority and should yield to the primary water uses.

Map number 4 shows the locations of the primary water uses in the basins.

Public and Industrial Water Supplies

From the standpoint of population served and rate of consumption, the use of underground waters is of equal importance to the use of surface waters for public supplies in the basins. However, there are over four times as many communities using underground sources as there are utilizing surface sources. The large number of smaller communities developed supplies from underground sources principally for economic reasons, whereas the larger cities resorted to surface supplies for reasons of adequate supply and quality or availability.

An inventory of public water supplies in the basins shows that 269 communities utilize surface waters for public supplies and serve 2,633,000 persons with an average of 327 million gallons daily. Underground waters are used by 1,136 communities and serve 2,825,000 persons with an average of 289.5 million gallons daily.

The erratic stream flows in the western portion of the basins limit the use of the surface waters for public supplies and therefore, underground water sources are used more extensively for this purpose. In the reach of the Arkansas River beginning at Wichita, Kans., the underground waters are highly mineralized mainly from contact with natural saline deposits. In localized areas the water is useable but, due to high mineralization, it is undesirable for public water supplies.

Surface waters are more plentiful and are used more generally for public supplies in the central portion of the basins. The large centers of population in the Verdigris and Grand (Neosho) River Sub-Basins and most large cities on the main rivers to the south and east utilize surface waters primarily for reasons of available quantity.

In the lower White River Basin and extreme eastern portion of the major basins, underground waters are abundant, are of good quality, and are used almost exclusively for public supplies. In Louisiana, however, a few large cities, including New Orleans, use the Mississippi River and other streams for sources of public supplies.

Adequate data to indicate the magnitude of the industrial use of the water resources in the basins are lacking. Only limited information concerning industrial water use in specific areas is included here and should not be interpreted as representative of this important water use throughout the basins. Recently developed methods in oil production operations are utilizing large quantities of surface waters for "flooding" of oil fields. This procedure consists of pumping surface water into the oil bearing strata to displace the residual oil in the sands and thereby increasing the yield from the wells. In some areas, however, considerable difficulties are arising from water flooding operations which are polluting the intermediate water bearing strata through abandoned and improperly plugged wells. It is reported that three oil refineries on the Verdigris River alone pump an average of 11.6 million gallons daily from the river. It is also estimated that in 1949, industries located in the State of Arkansas used about 25 million gallons of water daily from underground sources. Large industrial enterprises in Louisiana, including paper mills and oil refineries, use considerable quantities of water from the streams in that State.

Agricultural Use

Irrigation is essential for the support of truck farming in the western regions of the basins extending from the foothills of the Rockies to western Kansas and Oklahoma. Rainfall in this region varies from less than 20 inches in the Colorado and New Mexico portions to 20-25 inches in Kansas and the Panhandles of Texas and Oklahoma. The needs for livestock water are of equal importance throughout this vast cattle raising area.

The principal existing development of irrigation in this region lies along the main stem of the Arkansas River in Colorado, where in excess of 300,000 acres are irrigated. Several smaller irrigation developments, including the Tucumcari and Altus projects are located along the Canadian River in New Mexico and North Fork and Red Rivers in Oklahoma. These developments are supplied by impoundments and by direct diversion from meager stream flows and from shallow underground sources. Farther east, partly within the Red River Basin and extending southward beyond the major basin boundary, there is a large area of over a million acres irrigated primarily from underground sources.

Practically all areas are urgently in need of supplemental water. Ground waters in the Colorado and New Mexico portions are adequate only to furnish some of the needs of rural domestic supplies and stock water. Some supplemental supply may be obtained by conservation measures, but importation of waters from other river basins is considered essential by some water conservation authorities to provide an adequate supply for all uses in the upper Arkansas River Basin.

Although underground water sources are more extensive to the east, this source cannot be exploited without limitation and it has been considered necessary to augment the ground waters from surface sources to supply the needs for optimum development of the agricultural activities in the region.

In the central region of the basins the annual rainfall averages from 25 to 35 inches. Dry farming and cattle grazing are the dominant land uses. Irrigation is beneficial but is not practiced to the extent it is utilized in the western region. The precipitation is sufficient to support fair yields in most years. Runoff to the streams is characterized by relatively frequent and intense floods and long periods of negligible flow. This condition accentuates the serious soil erosion, stream sediment and flood control problems and necessitates conservation developments to utilize the surface water resources fully.

The eastern region of the basins includes the entire White River watershed and immediate drainage to the Mississippi River from Cairo, Ill. to the Gulf of Mexico. Rainfall in this region averages about 35 inches in the west to more than 50 inches in the east and south.

General agriculture is confined largely to the bottom lands along streams and rivers. The eastern-most portion consists of flat, low-lying area which is devoted principally to the raising of rice and cotton. In the Grand Prairie area of Arkansas about 450,000 acres are irrigated from underground sources for the production of rice exclusively. The use of ground water has been seriously over-developed in the Grand Prairie area and a replacement supply of surface water is required to maintain and expand the rice industry in addition to permitting recharge of the water-bearing strata to provide adequate water supplies for other uses.

Other extensive irrigated rice growing areas are found in southwestern Louisiana. These areas are irrigated from surface sources which are abundant but subject to industrial waste pollution primarily from oil production operations. The principal water resource problem is not one of adequate supply but one of better regulation of surface flows, involving pollution and flood control and drainage.

Recreational Uses

The principal recreational uses of the surface water resources in the basins include fishing and hunting. Bathing is of local importance but development of this use near centers of population where it would be beneficial is hampered by pollution of the available waters. Boating is popular on the navigable streams and the large impoundments throughout the eastern half of the basin area. Extensive national forests and a national park have been developed in the picturesque mountainous regions of the eastern portion of the basins and are attractive for camping and picnicking to thousands of visitors each year.

Fish and wildlife resources are an important and valuable national asset found in fair share within the area of the basins. In 1949, for example, hunters and fishermen in the United States purchased 28 million licenses at a cost of more than 67 million dollars. In addition to the cost of their licenses, these sportsmen spent an estimated additional 2 billion dollars for equipment and travel in pursuit of this recreational activity. Of this large sum, probably about 300 million dollars were spent in the States lying wholly or in part within the area of the major basins.

Valuable trout fisheries are found in the clean headwaters of the Arkansas River. Natural conditions, including erratic stream flows and silt pollution in the middle reaches of the Arkansas and Red Rivers in Kansas, Oklahoma, and Texas, limit the propogation of the higher type fishes to lakes and artificial impoundments. Some game fishing is available in the upper reaches of the Verdigris and Grand (Neosho) rivers.

The eastern portion of the basins, including the White River watershed, supports the greatest existing and potential fish and wildlife resources in the Southwest. Game fishing in the White River and duck hunting in the overflow areas of the main rivers enjoy national reputation in the sports field. Stuttgart, Ark., is noted as the duck hunting center of the Nation. This region also supports an abundance of other wild game.

Several areas of the basins have been developed for the preservation and restoration of fish and wildlife resources in the surface waters. The largest of these developments are located on the lower reaches of the White River, on several large impoundments throughout the central portion of the basins and quite extensively in the swamp and marsh areas of Louisiana. In the last 12 years, Federal funds amounting to more than 8 million dollars have been allocated to the States in the area for wildlife restoration purposes. There are also eight fish culture stations established throughout the basins. In 1949, the production of the eight hatcheries in the White River, Arkansas River and Red River basins totaled about twelve and one-half million eggs, fry, fingerlings and adult fishes.

Commercial Fishing

Commercial fishing activities are carried on principally in the waters of the eastern and southeastern regions of the basins. Some commercial fishing is done on the lower Verdigris River. More extensive operations are found on the White River and major tributaries. Shellfish are also taken from the White River to supply the button manufacturing industry located along the lower section of the river.

Yield from the upper inland streams, however, comprises only a small part of the total production and value of this important resource. The network of streams and watercourses in Louisiana, including the marginal Gulf waters, are noted for their abundance of shellfish; shrimp and other fishes. Fish canneries and fish oil factories are an important part of the economy in the area.

Of significant commercial value in the marshes and swamps of the coastal marginal waters is the muskrat farming and trapping industry. Pelts from this area supply a large part of the fur market which is valued at many millions of dollars annually.

Power Development

The potential capacity of the basins' surface water resources for hydro-electric power has, by no means, been fully exploited. It is stated that future needs will greatly exceed their potential capacities.

The existing power development projects in operation, and those under construction, are located in the eastern portion of the basins where the topography and stream flows are suitable for their construction. Four projects are located on tributaries of the Arkansas River in Oklahoma, namely, the Caney River, Verdigris River, Grand (Neosho) River and Illinois River. The combined installed capacity of the power units is 165,000 kilowatts. Two projects, with an installed capacity of 230,000 kilowatts, are located on the upper White River and a single project with an installed capacity of 70,000 kilowatts is located on the Red River near Denison, Texas.

In addition to provisions for increased power production, the projects are designed to provide about nine million acre-feet of flood control storage.

Navigation

Navigation on the Arkansas, White, and Red Rivers is limited to the lower reaches of these rivers. The Mississippi River, which is one of the largest navigable inland waterways of the Nation, traverses the eastern portion of the basins from Cairo, Ill. to the Gulf of Mexico, a distance of nearly 600 miles. Several smaller rivers in Louisiana, including the Calcasieu River, Atchafalaya River, Bayou Teche and Bayou Lafourche are navigable for considerable distances from the Gulf. Ocean-going vessels ply the Calcasieu River to the industrial city of Lake Charles. The Intracoastal Waterway, which traverses the entire width of Louisiana, provides an important link in the East-West water transportation system of the Nation.

Transportation on the Arkansas, White, and Red Rivers is of local importance only and is limited in volume and to products of the area. The Mississippi River on the other hand, is the main waterway into the heart of the Nation and provides an important means of transportation for interstate traffic and also foreign trade. The river is navigable from the Gulf to Minneapolis, Minn., and according to data from the "Annual Report of the Chief of Engineers, U. S. Army", in excess of 57 million tons of cargo were carried on the entire course of the river during 1948. A considerable portion of this volume of Cargo was transported within the limits of the basins and more specifically to and from the large port of New Orleans. Data from the same source shows that in 1948, nearly 35 million tons of cargo were transported on the reach of the Mississippi River from New Orleans to the mouth of the passes in the Gulf.

The importance of the Intracoastal Waterway as a water transportation route in these basins is also represented on the basis of volume of cargo carried. In 1948, the movement of cargo in the section from New Orleans to the Sabine River in Texas, amounted to almost 17 million tons. During the same period, the movement of cargo in the section of waterway from New Orleans to Mobile, Ala., although substantially less, amounted to about two and one-half million tons.

POLLUTION CONTRIBUTED TO WATER RESOURCES

Tables A and B, herein, summarize the available information on the extent of pollution originating from municipal and industrial sources which is discharged to the waters within the major basins area. Map No. 1, entitled "Sources of Pollution", presents a pictorial summary by sub-basin of such data.

There is a total of 821 municipalities with sewerage systems in the basins. These municipalities have a combined population of 4,961,100 connected to sewers which contribute domestic wastes, in raw or treated state, to the watercourses. Estimates of the amount of pollution discharged to the watercourses represented in terms of equivalent number of people (population equivalent) are available for about 70 percent of the municipalities, representing about 60 percent of the total population connected to sewers. The estimated pollution load from 564 municipalities, having 2,809,700 persons connected to sewers, has a population equivalent of 1,931,600. Although the original pollution load is reduced by treatment in a substantial number of municipal plants, industrial wastes of an organic type discharged to municipal sewers impose a considerable additional load over and above that originating from the sewered population.

Data regarding the extent of pollution from industrial sources discharging directly to watercourses are recognized as incomplete and should not be considered as representing the true magnitude of the industrial waste pollution problem in the basins.

There are 1,081 sources of industrial pollution reported which discharge wastes in a raw or treated state to the watercourses. The estimated pollution load contributed by 32 sources producing organic wastes is equivalent to the domestic wastes from a population of 1,355,600.

The pollution load contributed by an additional 248 plants also producing organic wastes is undetermined. One hundred and twenty industrial sources produce inorganic wastes which exert a definite polluting effect on the streams but which cannot be readily represented on a common unit basis with organic type wastes. An additional 763 sources are reported as producing wastes of undetermined types.

The pollution of streams from municipal wastes is of greatest importance in the central region of the basins and in southern Louisiana where the large centers of population are concentrated. Organic wastes from industrial sources are produced mainly from the processing of food products. These industries, which include meat packing plants, milk, and cheese plants and canneries are found generally in the central and northeastern regions. Other industries which produce wastes of a similar nature are the paper mills located in the eastern region extending from the Ouachita River area to southern Louisiana and the sugar refineries which are located mainly along the rivers in south central Louisiana.

Pollution from industrial activities producing inorganic wastes is one of the major problems in the basins. The disposal of oil well brines and waste oils from oil production and refining operations is the most important source of pollution of this type contributing to the degradation of the water resources. The magnitude of these operations spread throughout the east-central and southeastern regions of the basins has resulted in extensive pollution of both the surface and underground waters in and adjacent to the oil producing regions. The difficulties encountered in developing suitable disposal methods for these wastes, especially those from old or marginal producing wells, present complex economic problems which hamper efforts for abatement of this type of pollution.

Pollution originating from soil erosion and carried in the streams as silt is of major importance in the main rivers of the basins. The Mississippi River by virtue of its capacity is known to carry a silt load of huge magnitude. Silt in the Mississippi, however, originates from its large tributaries including the Missouri River to the north and the Arkansas and Red Rivers within this area. The amount of silt carried in the rivers is indicated by information available for the Arkansas River which in the magnitude of its sediment load ranks fourth among the large rivers of the United States. Measurements made at Van Buren, Ark., show that 107 million tons of silt are carried past that station annually.

Other sources of inorganic pollution associated with the bituminous coal, lead and zinc mining and related processing operations are found in the headwater areas of the Arkansas, Verdigris, and Grand (Neosho) rivers and wastes and mine tailings from these operations are considered mostly local problems.

In addition to sediment, natural pollution caused by mineralization is one of the factors which limits the use of the surface waters in the upper Arkansas and Red Rivers for municipal and industrial purposes. The courses of the main rivers and principal tributaries throughout the highly mineralized regions of southeastern Colorado, western Texas, Kansas and Oklahoma impart high mineral content to the waters which is aggravated because of the low flow conditions in the streams. Although increased dilution available in the lower Arkansas and Red Rivers tends to decrease the concentration of these minerals, their effect on water uses is apparent as far downstream as Little Rock on the Arkansas River and through Louisiana on the Red River.

Table A. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	564	2,809,700	1,931,600
Having population data available (Data on pollution load to watercourse incomplete or not available)	257	2,151,400	—
Total	821	4,961,100	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	32	1,355,600
Producing organic wastes	248	Undetermined
Producing inorganic wastes	[1]120	—
Producing wastes of undetermined type	763	Undetermined
Total	[2]1,081	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes 82 plants also listed as producing organic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

DAMAGES TO WATER RESOURCES FROM POLLUTION

The damages from pollution to the water resources in the area may be considered under two general categories, namely the existing or specific damages and the potential damages which may result from the use of polluted waters or which may restrict various developments dependent on the optimum utilization of the waters available.

Specific damages to the water resources for nearly all primary uses have resulted, in most part, from the discharge or disposal of oil well wastes to the surface and underground waters. In the central and eastern regions where municipal and industrial supplies are the principal water use, it has become necessary for many municipalities and industrial plants to incur increased costs for water treatment or abandon their present supplies for other suitable sources. In some cases ground water sources were utilized if adequate, however, in other instances the ground water supplies were similarly polluted or inadequate and supplies had to be developed on remote watersheds at great cost.

Complaints of long standing regarding the tastes and odors in the municipal water supplies using the Verdigris River waters are common record. The City of Tulsa, Okla. has constructed a water transmission line across the Verdigris River to tap the surface waters in the Grand (Neosho) River basin. In 1934 it became necessary for the City of Little Rock, Ark., to abandon the Arkansas River as a source of supply in favor of an impoundment on a tributary stream. Numerous similar cases of damages are public knowledge but are not supported by readily available records or evaluated on a monetary basis.

Agriculture, which is one of the primary economic activities in the basins, has been affected from the discharge of these wastes into the watercourses. Water high in chlorides is unsuitable for irrigation because its use greatly reduces the yield of crops. Rice is one of the principal crops damaged by water polluted with oil well brines.

Damages to timber and farm lands have resulted from polluted waters flooding local areas in southern Arkansas. Brines and oil waste oils have been deposited on the lands and have destroyed valuable timber and rendered farms unproductive. Other areas in Arkansas, Louisiana, and Oklahoma that have been damaged by oil well brines are plagued by salt marsh mosquitoes which breed in the brackish wastes.

An adequate supply of clean water is essential for stock watering purposes. In several instances polluted waters have been fatal to livestock and its use is known, in general, to retard the development of cattle and other stock. To provide suitable water for stock ranges along polluted streams, it has become necessary to incur the expenditures required to develop supplies from limited underground sources, or construct farm ponds.

Damages to fish and wildlife are real indices of pollution and are recognized as evidence of critical conditions in the waters affected. Numerous instances of "fish kills" are reported in the streams of the basins. In chemically polluted water, the fish have been tainted and rendered unsuitable as a food. In most cases, however, pollution has destroyed the aquatic plant and animal life utilized as food by fishes and also affected their spawning grounds. The destruction of food supplies and changes in environment affecting the propagation habits of fish and other wildlife has driven these species from numerous watercourses at great loss to one of the most important recreational outlets enjoyed by a majority of this inland population.

Although domestic sewage and other municipal wastes are discharged in large quantities to the watercourses, either raw or with varying degrees of treatment, the impact of this pollution load has not been a general problem. Specific reports are available of "open sewer conditions" in some local streams. In most areas, domestic wastes of significance are discharged into streams already polluted by other types of wastes and are occasionally considered of secondary importance. The impact of these wastes upon the waters, however, cannot be minimized when considering the overall damages to the water resources.

A discussion of the damages resulting from silt pollution will be confined to those damages associated with the uses of the polluted waters in the streams. It is recognized that substantially more damages are suffered by the land resources from loss of valuable soils important to the agricultural economy of the basins.

Heavy silt loads carried by streams used for municipal and industrial water supplies increases the cost of water treatment for such use. The increase in cost is incurred through greater operating expenses and, in some cases, by requiring adjunctive facilities needed to maintain capacity.

Silt deposited in streams and impoundments is detrimental to fish and other aquatic life. Important fish habitats have been destroyed by the deposition of silt over the sources of food supply and spawning grounds.

Siltation of reservoirs tending to decrease the useful life of the projects is an important item in the consideration of the cost and feasibility of such developments.

Extensive dredging for maintenance and project development of water transportation routes is made necessary by the large sediment loads carried by the streams. Large sums of Federal funds are spent annually for aid-to-navigation projects in the basins.

Because of the vast areas of undeveloped land and relatively light concentration of population over much of the area, the pollution problem has not become extensive and serious damages to the water resources has been confined mainly to the central and eastern regions. Real and specific damages to the waters in these regions have been cited previously and mention will be made here of the potential damages which may affect the public health and welfare of the inhabitants and general economic development of the entire region.

Extensive use of surface waters for irrigation of garden crops in the arid and semiarid areas of the western portion of the basin has definite public health implications. The discharges of untreated or inadequately treated sewage into streams used for this purpose is recognized as a potential health hazard of growing significance. It is further recognized that the potential dangers to the public health will increase as the population in the region grows and irrigation developments are expanded to meet the market demands.

Pollution of the water resources, either natural or man-made, can hinder the industrial development of an area to a great extent. Labor and material incentives may be favorable for the establishment of industrial enterprise, yet unsatisfactory water supply either as to quantity or quality may dictate the location to other regions with more suitable supplies. In a similar sense, existing economic activities may be deprived of expansion opportunities. Irrigation developments in the basins have been restricted to some extent by inadequate water supplies in terms of both volume and quality.

Development of recreational bathing facilities in the streams adjacent to the centers of population where they would be most popular have been hampered by pollution of these waters. Existing facilities are found, for the most part, on lakes and impoundments away from the convenience of many. Restoration of the waters for the potential development of local recreational areas is recognized as a right of the people and an asset to the general well-being of the community.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

In the consideration of benefits resulting from pollution prevention and abatement, it can be stated generally that all legitimate water uses enjoy some degree of benefit, either directly or indirectly, from a program of pollution control. In a broader sense, the benefits may be applied to the conservation and development of our fundamental human, land, and water resources. In some cases, the benefits can be evaluated on a monetary basis and considered as tangible benefits; more frequently the intangible benefits, equally real and justified, cannot readily be assigned a specific or dollar value.

In the western region of the major basin where the water resources are limited and conservation measures are a paramount need, existing pollution prevention and abatement measures and reuse of the waters for optimum utilization are beneficial to the development of the agricultural and industrial potentials of the area. Throughout the central and eastern regions, where the supply of water is not acute, pollution from municipal and industrial sources has degraded the quality of waters in a number of local areas and has restricted the full utilization of the waters available.

The primary water uses within the basins have been discussed previously and include such uses as public and industrial water supplies, agriculture, recreation (including game fish and wildlife propagation), commercial fishing, power development, and navigation.

Some specific and potential benefits to the various water uses are discussed below together with effects upon the health and welfare of the people and the land resources in general.

The use of polluted waters for public water supplies adds to the cost of treatment facilities and operation, presents a potential health hazard, and often produces a processed water which is unpalatable and undesirable. Many communities utilizing polluted waters for sources of supplies are tolerating the expense and inconveniences to avoid large capital expenditures required to develop new supplies with the hope that pollution abatement measures will eventually restore the waters to a suitable quality. Other communities have developed supplies from underground sources or from clean tributary streams but are faced with a present or future prospect of a water shortage due to the steady population growths and increases in industrial demands. The case of the City of Little Rock, Ark., is cited as a specific example of such a situation. In 1934, it became necessary for Little Rock to abandon the Arkansas River as its source of supply in favor of an impoundment on a small stream. This project required the acquisition of land, construction of a dam, and a transmission line 40 miles long. It is anticipated that the future needs of the city will require a major expansion of this supply or the development of an entirely new supply. The prospects of resorting to the Arkansas River for public water supplies can hardly be considered in view of the unsatisfactory quality of the river water resulting primarily from natural mineral content, silt, oil well brine and some sewage pollution.

Pollution abatement and restoration of the waters to suitable quality for use as public supplies will directly save numerous communities the expense of continued high treatment costs and financial burden of developing new supplies from sources of clean water. In addition to savings in treatment costs and expenditures for development of new supplies which can be evaluated readily on a dollar basis, there are the intangible benefits associated with the protection of health and well-being of the population dependent upon an adequate supply of safe and palatable water.

Industrial water use in the basins is affected by pollution to the same relative extent as public water supplies. Numerous industries obtain their water needs from public systems. These industries, however, have to pay their share of costs for the development and treatment of public water supplies through high water service rates. Other industries have to develop private supplies from suitable underground and surface sources or incur continual high water treatment costs and plant operation and maintenance expenses resulting from the use of polluted water. An adequate supply of water of good quality is essential for industrial operations and is reflected in lower production costs; it fosters expansion and encourages the location of new industrial enterprises essential for the economic development of the area.

It has been demonstrated in numerous instances that industrial waste treatment measures often result in the conservation of valuable resources through recovery of raw materials or salvage of by-products and can be justified readily as a financial benefit to the industry. The benefits resulting from the disposal of oil well wastes, which is considered a major pollution problem in the basins, are unique in this respect.

Methods developed in oil production operations and associated waste disposal practices utilize the oil well brines for reinjection or flooding of the oil bearing strata to maintain the pressure in the sands and to displace the residual oils for ultimate yield. The disposal of oil well wastes to the substrata, through reinjection and flooding practices which are recommended by many water pollution control agencies, is contributing greatly to the prevention and abatement of water pollution, is generally an economic benefit to the producers from increased yields, and ultimately results in the conservation of important petroleum resources.

There are records of a number of cases in the basins where pollution from industrial sources has resulted in sustained damages to various kinds of riparian water uses. Conscientious pollution control by industry will result in financial benefits through protection against claims for such damages and also promote desirable public relations essential to the development of industry and the basins' economy.

Limited water resources and pollution have restricted the development of agricultural activities in several areas within the basins. Irrigation of expansive truck crop producing areas in the upper Arkansas River region has been restricted primarily because of the limited supply of water available. The use of clean water for irrigation of truck crops particularly will permit the optimum utilization of the waters available and reduce the ever-present hazards to public health. The spread of diseases associated with the use of polluted waters for the irrigation of low-growing truck crops which are consumed in the raw state is of important public health significance.

Throughout the arid areas of the basins, sewage effluents are used appreciably to irrigate stock feed crops and other crops of no public health significance. The disposal of sewage in this manner results in benefits to the individual communities from savings in treatment plant requirements, and in financial returns from the sale of effluents. The disposal on land is also a benefit to pollution abatement by eliminating the wastes from the watercourses.

Pollution control is also considered of paramount importance in the oil producing region of western Louisiana where considerable acreage devoted to rice culture is irrigated from the streams in the area. The availability of clean water for irrigation purposes increases the yield of the rice crop and similarly benefits the production of other irrigated crops.

Livestock raising is one of the most important economic activities in the basins. Clean water is essential for the healthy development of livestock. Livestock losses resulting from the use of polluted waters can be prevented and the high costs incident to the settlement of damages can be avoided through pollution abatement measures.

Recreational uses including fishing, hunting, and bathing, that have been damaged or such activities driven to remote areas by the steady encroachment of pollution can be restored convenient to centers of population and made available to a greater number of people. The national reputation enjoyed by the hunting and fishing opportunities in the basins are being jeopardized and conservationists are advocating the development of propagation areas and pollution control to preserve this important asset. Pollution prevention and abatement benefits the aesthetic value of waters and makes them attractive for other forms of recreation including boating and picnicking. The value of land suitable for recreational developments or other purposes is enhanced or restored in general in proportion to the improvements in the aesthetic qualities of the streams.

Important commercial fishing, including the production of shellfish, in the Gulf waters have been damaged from silt, domestic, and industrial pollution. Pollution control in the streams discharging to these waters will promote increased yields and permit utilization of shellfish producing areas now restricted for public health reasons.

The benefits to power developments and navigation are not significant in these basins but are mentioned in general for completeness The control of silt pollution is the important single factor affecting power and navigation uses. Some industrial wastes with corrosive properties also cause damage to installations and equipment. The useful life of power projects free from the effects of pollution is increased and maintenance costs are decreased. Large expenditures of Federal and local funds for aid-to-navigation projects can be reduced by the control of silt pollution. The greatest benefit from silt pollution control, although not considered within the province of this report, results in a greater degree from the conservation of the lands for the development of the agricultural economy in the basins.

There are numerous other benefits of indeterminate value resulting from pollution prevention and abatement which can be associated with some of the specific benefits discussed above.

It should be remembered that most important of all is the responsibility of this generation to use but not abuse the fundamental resources of the land and to practice conservation--through water pollution control or other methods which are applicable--for the benefit of those who are to follow. A nation lacking in renewable resources of land and water is an impoverished nation.

POLLUTION PREVENTION MEASURES IN EFFECT

The concept of pollution control is not new in the basins. As early as 1907, the State of Kansas passed legislation for the prevention of stream pollution and as the necessity arose in other areas, various State agencies were vested with authority to administer laws relating to the discharge of wastes and the abatement of pollution within the limits of their jurisdiction.

Gradual progress is evident in the development of measures for pollution prevention in the several States within the basins. These measures included supplementing existing laws, establishing administrative agencies and formulating programs for promoting pollution control activities. In addition to the State laws which apply to pollution control, relatively recent Federal legislation has been passed to assist the States in their activities.

The provisions of Public Law 845 have stimulated water pollution control activities in the basin by making grants available to State agencies for conduct of investigations, research, survey and studies related to the prevention and control of water pollution caused by industrial wastes. This piece of legislation has also stimulated cooperation between the State and Federal agencies concerned with water pollution in efforts toward a solution of the problems. Public Law 352 provides for financial aid in the form of non-interest bearing loans to communities for planning waste treatment facilities and other public works.

The formation of the Arkansas-White-Red Basins Inter-Agency Committee should add impetus to the growing interest in pollution control. The Committee is authorized to formulate an integrated and comprehensive plan for the development of the land and water resources within the boundaries of the three river basins. Authority for the study was established in Section 205 of the Flood Control Act of 1950. The Committee is also directed to coordinate the interests and views of each Federal department concerned and to embrace the concurrence or comments of each State affected. The work of the Committee is supported with active participation by Federal and State agencies, group organizations and individuals. Representation of the various agencies and groups in the consideration of the problem related to the water resources is promoting unified action among all having interests in pollution control. The work program of the Committee will foster field investigations and studies within the basins for the purpose of compiling adequate data and information considered necessary to determine the scope of the pollution problems and to formulate a plan of corrective measures.

As part of the program services of some State water pollution control agencies, educational activities are carried on for the instruction of waste treatment plant operators and to provide public information to select group organizations, public officials and industry. Consultation is also rendered on sewage and industrial wastes problems and plant design review and permit issuing services are maintained to insure construction of adequate and useful waste treatment facilities.

Data available regarding existing municipal waste treatment plants indicate that some type of treatment is provided by 644, or 78 percent, of the 821 municipalities having sewerage systems. The population served by treatment facilities is 2,775,900, or 56 percent of the total sewered population of 4,961,200 within the major basins.

Table C shows that 303 municipalities provide for primary treatment in 310 plants serving a population of 894,400 and in addition to these, 341 municipalities provide for secondary treatment in 352 plants serving a population of 1,827,300. One hundred and eighty-three municipalities, with a total population of 2,185,300 do not provide for treatment of wastes discharged to the watercourses.

It is recognized that the data regarding industrial sources of pollution are generally inadequate to represent a fair picture of the pollution problems associated with industrial activities in the basins. Table D shows that a total of 1,081 industries are reported as discharging wastes directly to the watercourses. Of the total number of industries, only 68 are known to have some type of waste treatment facilities and 141 are indicated as having no treatment facilities. Of greater significance, however, to point out the need for more and detailed information regarding industrial waste pollution, is the fact that the status of treatment facilities is undetermined for 872 industries reported.

Map No. 2 shows the number of existing municipal and industrial treatment works in each of the 21 sub-basins included in the major basins area.

It should be noted that the foregoing data do not necessarily represent the relative amount of pollution abated from the watercourses of the basins. In many communities the plants are obsolete in design or greatly overloaded due to growth in population and increase of industrial activities utilizing public sewers for disposal of wastes. In the case of many municipalities and industries alike, facilities are provided for partial treatment or for the recovery of only a small portion of their total wastes. Of equal importance in the consideration of the effect of existing treatment works toward the reduction of pollution is the factor of plant operation and maintenance. Too often, adequate treatment works are rendered inefficient, and partial or inadequate facilities are rendered useless through poor operation and neglected maintenance.

Table E shows that of the existing 662 municipal plants, 270 are satisfactory, 377 are unsatisfactory and 15 are undetermined with relation to the capacity of the works. Information regarding adequacy with relation to operation, indicates that 324 plants are operated satisfactorily, 308 plants are not operated satisfactorily and the method of operation for 30 plants is undetermined. Similar information for industrial waste treatment facilities indicates that of the 68 plants reported, 14 are satisfactory, 18 are unsatisfactory and the adequacy of 36 is undetermined with relation to capacity of the facilities. Operation of the industrial facilities is reported satisfactory for 28 plants, unsatisfactory for four plants and undetermined for 36 plants.

Information contained in table F shows the number of municipal waste treatment plants and the capacity, in terms of design populations, of the plants that were constructed during the years 1946 to 1950 inclusive. A summary of the data shows that 48 projects, with a combined capacity to serve about 229,000 persons, were completed during the five-year period. It is known that due to restricted use of critical materials and other factors, few waste treatment plants were constructed during the years of the last war, and for all intents and purposes, it can be assumed that the majority of the older municipal plants are approaching obsolescence except in those cases where changes in processes and expansion of the works have been made as the needs arose. Similar information regarding construction of industrial waste treatment facilities indicates that eight projects, with a combined capacity capable of serving an equivalent of more than 78,000 people, were completed during this period.

Table C. Existing treatment facilities, municipal

Degree of treatment provided	Number*		Population served
	Municipalities**	Plants	
Primary	303	310	894,400
Secondary	341	352	1,827,300
No treatment	183	--	2,185,300

*Total number (827) does not agree with total of 821 shown in table A, due to multiple sources of pollution in some municipalities.

**Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having: Treatment facilities	No treatment facilities	Undetermined facilities
Manufacturing industries:				
Food and kindred products	151	13	77	61
Textile mill products	4	—	2	2
Lumber and wood products (except furniture)	6	1	3	2
Paper and allied products	6	5	—	1
Chemical and allied products	13	2	8	3
Products of petroleum and coal	20	10	5	5
Rubber products	1	0	1	0
Leather and leather products	2	1	1	0
Primary metal industries	7	2	3	2
Salt refining	3	0	3	0
Distillery	1	0	1	0
Railroad repair shop	2	1	1	0
Rendering	1	0	1	0
Miscellaneous	340	8	13	319
Not classified	444	—	—	444
Nonmanufacturing industries:				
Oil production industry	72	24	18	30
Other mining industries	8	1	7	0
Total	1,081	68	144	869

*Industries having separate outlets and discharging wastes directly to watercourse.

Table E. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	662	270	377	15	324	308	30
Industrial	68	14	18	36	28	4	36

Table F. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed*	Design population	Plants completed**	Amount of waste treated (in terms of equivalent number of people)
1946	3	13,300	1	1,500
1947	10	25,100	3	19,500
1948	16	78,800	2	57,000
1949	14	85,000	1	—
1950	5	27,000	1	—

*Includes seven plants with design population unknown.
**Includes three plants with P.E. unknown.

POLLUTION PREVENTION MEASURES REQUIRED

The specific actions necessary for the prevention and abatement of pollution are generally recognized even though there exist many wide gaps in the information available on the water pollution problems in the basins.

In some areas within the basins, the responsible agencies have made progressive gains in accomplishing abatement of municipal and industrial pollution. Notable achievements have been made especially in the control of oil field wastes. Development of disposal methods for oil field wastes is regarded as a fairly recent concept, dating back not more than 15 years. Restoration of many watercourses, damaged from the uncontrolled discharge of oil field and other wastes, has been handicapped in general by a lack of unified and concerted effort toward the abatement of pollution.

It is recognized that the primary responsibility for pollution control should rest with an agency of the State government. In those States where the existing administrative organization for water pollution control is considered inadequate, it may be deemed desirable and advantageous to change and supplement water pollution control legislation to enable the State agencies to strengthen their programs. Legislation may well include provisions for enforcement, for enabling acts, for financing waste treatment works, for increased funds for State programs, for permitting cooperative agreements or activities with other States when interstate problems are involved, and other desirable provisions deemed essential for the exercise of the responsibility vested with the designated agency.

Public Law 845 encourages the enactment of uniform State laws for water pollution control. While uniform legislation need not mean identical legislation, many benefits would be derived by the States if they adopted legislation uniform in basic principles. The underlying concept and purpose of uniform legislation is to facilitate interstate cooperation for a more concerted attack on water pollution.

Uniformity of statutory requirements will be an important step toward providing industry for the first time with the best possible definition of what is expected of it in the way of cleaning up its share of stream pollution especially where interstate streams are involved. The definition of pollution abatement requirements should help to reduce industrial pollution and encourage industrial development by providing assurance to industry of what is or will be required over a reasonable period of time.

At present, the State of Arkansas has water pollution control legislation which substantially includes all recommended features as contained in the suggested law drafted by the Public Health Service. Tennessee has a Stream Pollution Act placing the authority for control in the Stream Pollution Control Board. Although certain enforcement features of this Act were suspended during 1949-50, the 1951 Legislature returned this authority to the Board. Kansas and Texas are operating under State statutes which are considered adequate by the State authorities for the administration of their present water pollution control programs. Colorado and Oklahoma also have come to recognize the limitations of enacting piecemeal legislation and the lodging of concurrent water pollution control authority in several departments of State governments. These latter States are now in the process of developing legislation patterned after the uniform or suggested law. It is reasonable to expect that other States within the basins will take inventory of their statutes pertaining to water pollution and supplement or reconcile the laws for uniformity as the opportunity or necessity arises.

It is recognized that drainage basin areas with their inherent problems relating to water resources do not always respect political boundaries. Within the broad definition of an interstate stream, only few watercourses within the major basins can be considered as strictly intrastate or of local significance. Not until very recently have some of the States within the basins come to realize the value of the mechanism of interstate compacts and agreements as a means of solving common problems extending beyond their respective borders.

One interstate compact is in effect within the area of the basins, and two are in the process of preparation. The compact in effect is between the States of Colorado and Kansas, was signed by the President May 31, 1949, and deals primarily with apportionment of waters of the upper Arkansas River. The second compact between the States of New Mexico, Texas, and Oklahoma, dealing with the waters of the Canadian River, is awaiting ratification of the States and congressional approval. A third compact between the States of Texas and Oklahoma, dealing with waters of the Red River, is in the process of negotiations between the States. A significant interpretation within the scope of the provisions for an equitable distribution of the waters of interstate streams is applied to the

quality of water passing State lines. The respective States on an interstate stream may determine the extent to which one State may affect the quality of water passing to another State.

It has been demonstrated, through the operation of interstate compacts dealing with water pollution control involving 29 States throughout the Nation, that this device provides the approach to effective interstate cooperation. It is the policy of the Federal government to further the utilization of compacts and this policy is spelled out in Section 2(b) of the Federal Water Pollution Control Act, which directs the Public Health Service "to encourage the formation of interstate compacts."

The value of this device should be recognized and utilized to a greater extent by the several States within the basins as a means of controlling interstate pollution. It appears desirable at this time, from the information available, that the formation of compacts between the States concerned with interstate problems will strengthen them in their work, will result in more effective application of the Water Pollution Control Act, and ultimately accomplish desired pollution abatement and restoration of the important water resources.

A review of the information and data regarding water pollution in the basins indicates that serious pollution conditions exist in local areas but the problem is not extensive or basin-wide. Minor sources of pollution in the vast undeveloped areas are not considered of importance at present.

In States where the problems exist, early action programs should be inaugurated by the responsible agencies, in order to abate existing pollution and to stop the further exploitation of the watercourses. Desirable programs will require adequate administrative and technical personnel, necessary equipment and facilities, and sufficient funds for unrestricted operations. The programs should accomplish the comprehensive evaluation of the pollution problems, recommendations for their solution, and finally, the active sponsoring of remedial measures required.

In some States, inflexible municipal tax structures which limit financing methods for construction of waste treatment facilities have hampered water pollution abatement efforts. An examination of municipal financing methods as applied to sewage treatment works, is generally indicated to determine needed improvements in those methods. A similar study of methods to finance industrial waste treatment projects should stimulate interest toward the solution of the many and complex industrial waste pollution problems in the basins.

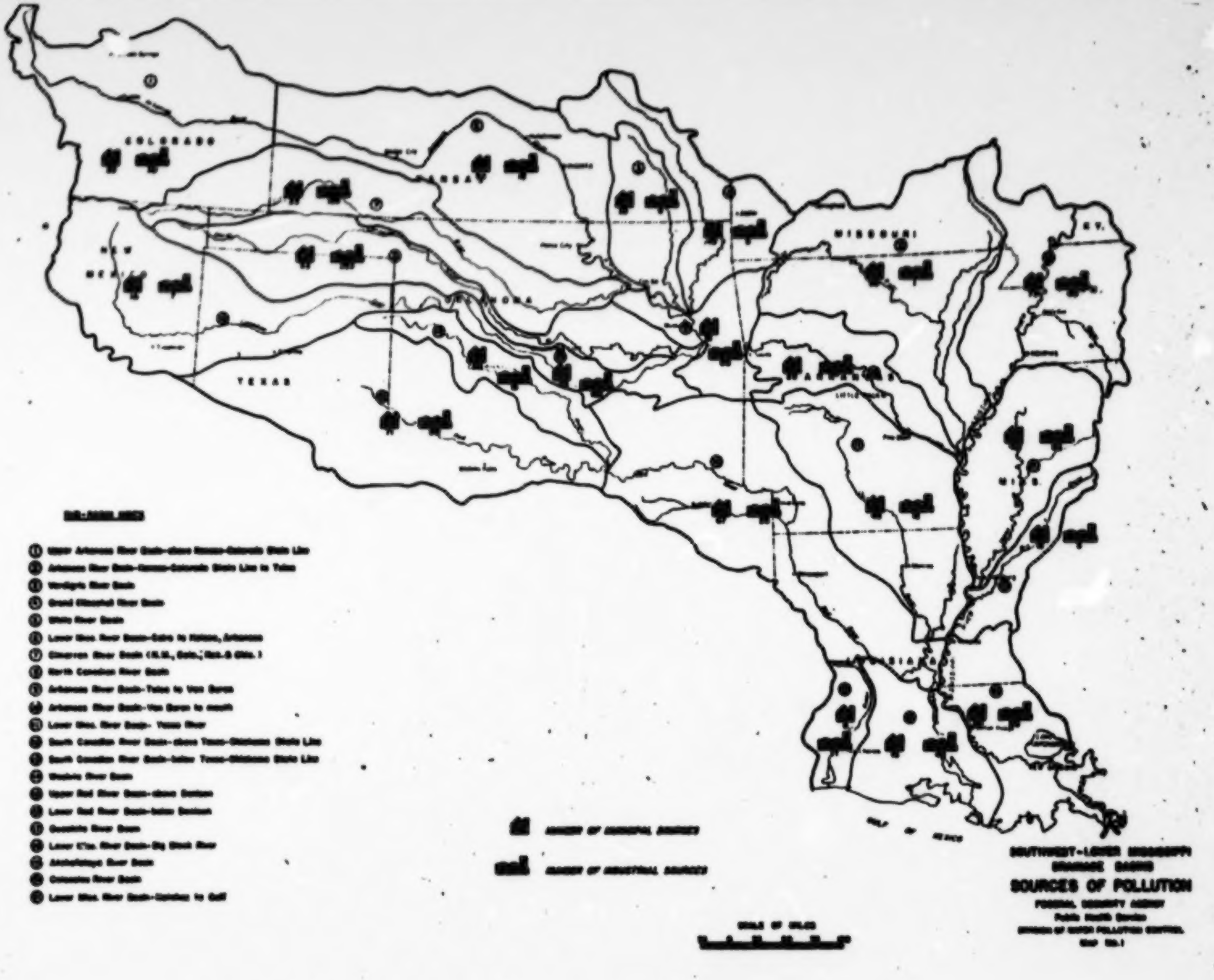
Data regarding sources of pollution, especially from industrial plants, are generally incomplete for a comprehensive evaluation of the pollution problems throughout the basins. A summary of available data, however, shows the immediate need for construction of waste treatment plants by a substantial number of municipalities and industries reported as sources of pollution affecting the water resources of the basins.

Table G shows that a total of 557 municipal waste treatment plants or improvement of existing facilities are required for adequate treatment of wastes discharging to municipal sewerage systems. Included in the total are requirements for construction of 132 new plants in communities not provided with treatment facilities, 251 improvement projects including enlargements or additions to existing plants, and the replacement of 134 existing plants regarded as totally inadequate. The requirements for 40 additional communities are undetermined. There are 289 municipalities with a sewered population of 2,007,500 in the basins which do not require pollution abatement projects. In this category are included the communities reported with adequate treatment facilities.

The inadequacy of the data regarding industrial sources of pollution is reflected by the large number of plants for which the waste treatment requirements are not available or are undetermined. Limited funds and personnel have seriously hindered the development of more complete data. The requirements for waste treatment facilities for 979 industries, of the total of 1,081 industries reported, are classified as undetermined. From the nature of the data available, it is impractical to attempt an estimate of the number of industries requiring waste treatment facilities of one type or another and the number requiring no projects.

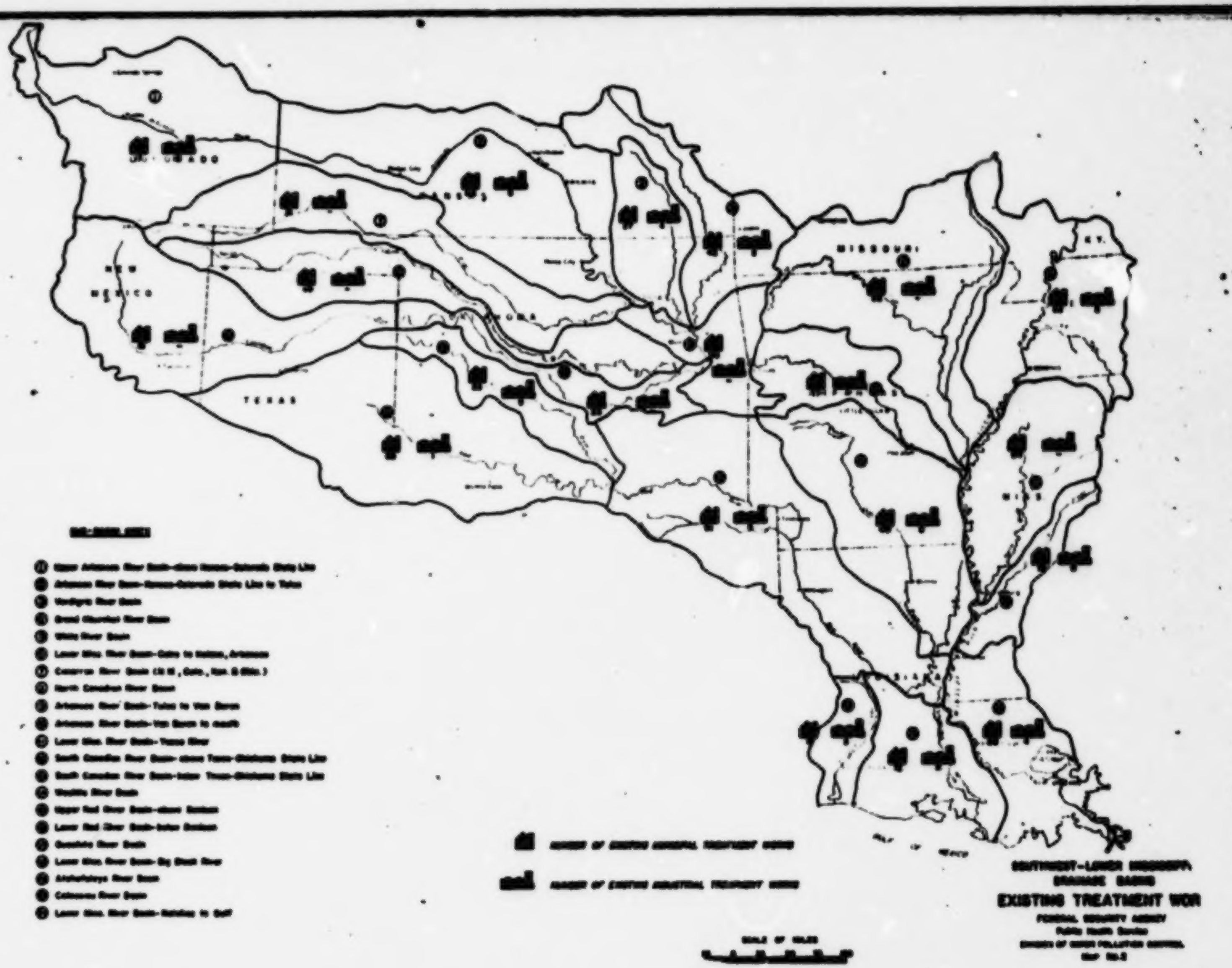
Specific industrial waste treatment requirements include 43 new plants and 20 improvement projects involving enlargements or additions to existing plants. One replacement of existing plants is reported and 42 industries have adequate waste treatment facilities or their wastes are not damaging the watercourses significantly to require waste treatment works.

An analysis of the data contained in table H, regarding the status of treatment works projects to abate pollution as of July 1, 1950, also indicates that inadequate progress is being made in efforts to control pollution in some areas. Of some 554 municipal waste treatment projects considered necessary for the abatement of pollution in the basins, only 86 are under active consideration, the status of action taken is at various stages from "abatement ordered" to "plant under construction". Of the remaining number, however, no formal action has been taken on 149 projects and the status of 319 projects is undetermined. The project needs for nearly 1,000 industrial sources of pollution reported are undetermined. Eight have plans under preparation and one has a project under construction.



SOUTHWEST-LOWER MISSISSIPPI
DRAINAGE BASINS
SOURCES OF POLLUTION
FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO. 1

SUB-BASIN INDEX
① Upper Arkansas River Basin-above Kansas-Colorado State Line
② Arkansas River Basin-Kansas-Colorado State Line to Tulsa
③ Verdigris River Basin
④ Grand (Neosho) River Basin
⑤ White River Basin
⑥ Lower Miss. River Basin-Cairo to Helena, Arkansas
⑦ Cimarron River Basin (N.M., Colo., Kan.& Okla.)
⑧ North Canadian River Basin
⑨ Arkansas River Basin-Tulsa to Van Buren
⑩ Arkansas River Basin-Van Buren to mouth
⑪ Lower Miss. River Basin- Yazoo River
⑫ South Canadian River Basin-above Texas-Oklahoma State Line
⑬ South Canadian River Basin-below Texas-Oklahoma State Line
⑭ Washita River Basin
⑮ Upper Red River Basin-above Denison
⑯ Lower Red River Basin-below Denison
⑰ Ouachita River Basin
⑱ Lower Miss. River Basin-Big Black River
⑲ Atchafalaya River Basin
⑳ Calcasieu River Basin
㉑ Lower Miss. River Basin-Natchez to Gulf
NUMBER OF MUNICIPAL SOURCES
NUMBER OF INDUSTRIAL SOURCES
SCALE OF MILES
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
MISSOURI
ARKANSAS
MISS.
KY.
GULF OF MEXICO


SOUTHWEST-LOWER MISSISSIPPI
DRAINAGE BASINS
EXISTING TREATMENT WOR
FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP No.5
SUB-BASIN KEY
Upper Arkansas River Basin-above Kansas-Colorado State Line
Arkansas River Basin-Kansas-Colorado State Line to Tulsa
Verdigris River Basin
Grand (Neosho) River Basin
White River Basin
Lower Miss. River Basin-Cairo to Helena, Arkansas
Cimarron River Basin (N.M., Colo., Kan. & Okla.)
North Canadian River Basin
Arkansas River Basin-Tulsa to Van Buren
Arkansas River Basin-Van Buren to mouth
Lower Miss. River Basin-Yazoo River
South Canadian River Basin-above Texas-Oklahoma State Line
South Canadian River Basin-below Texas-Oklahoma State Line
Washita River Basin
Upper Red River Basin-above Denison
Lower Red River Basin-below Denison
Ouachita River Basin
Lower Miss. River Basin-Big Black River
Atchafalaya River Basin
Calcasieu River Basin
Lower Miss. River Basin-Natchez to Gulf
NUMBER OF EXISTING MUNICIPAL TREATMENT WORKS
NUMBER OF EXISTING INDUSTRIAL TREATMENT WORKS
SCALE OF MILES
COLORADO
KANSAS
MISSOURI
KY.
NEW MEXICO
OKLA.
ARKANSAS
TEXAS
MISS.
LA.
GULF OF MEXICO

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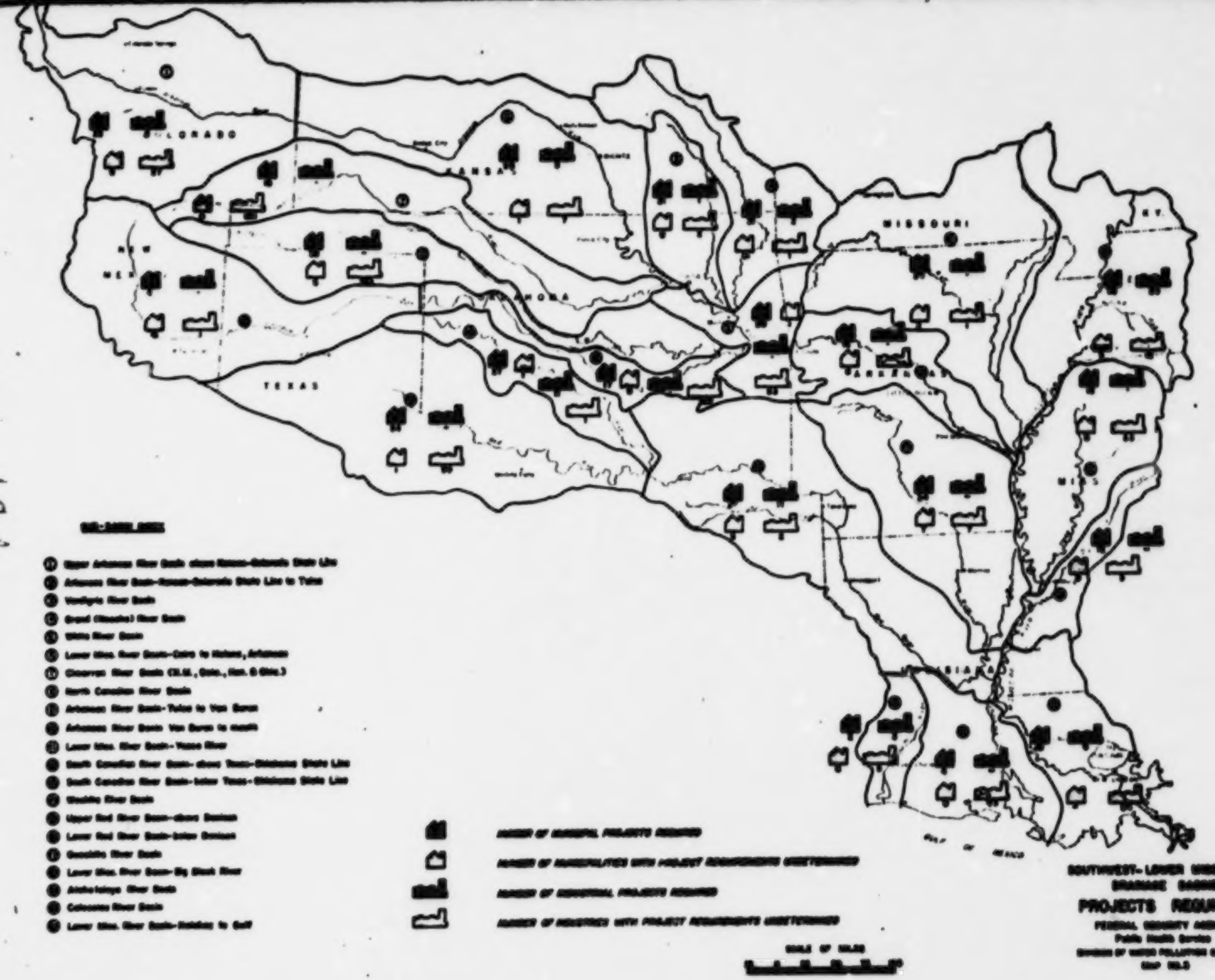
COLORADO
KANSAS
MISSOURI
KY.
NEW MEX.
OKLAHOMA
TEXAS
ARKANSAS
MISS.
LOUISIANA
GULF OF MEXICO
SUB-BASIN INDEX
Upper Arkansas River Basin above Kansas-Colorado State Line
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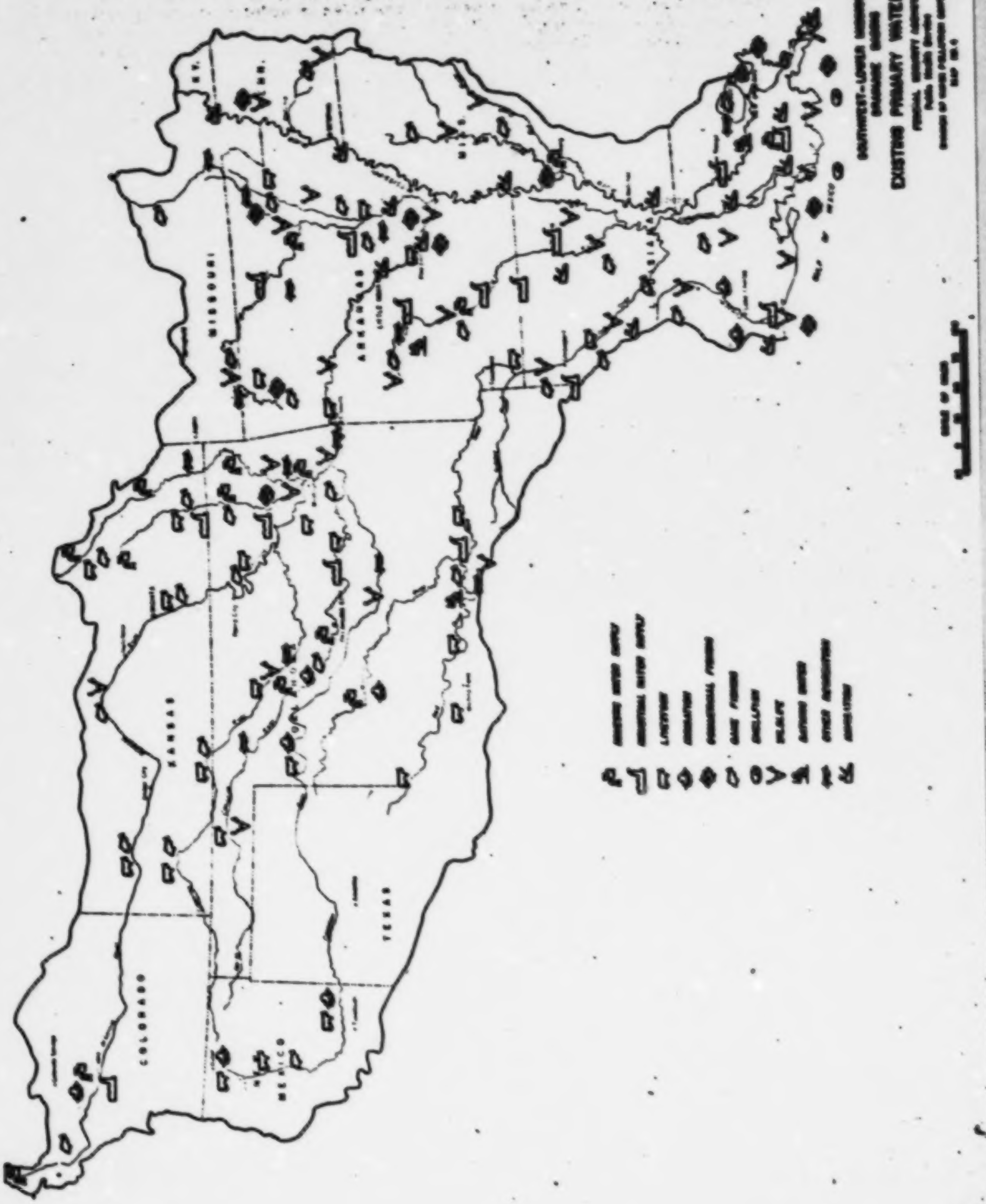
Cimarron River Basin (N.M., Colo., Kan. & Okla.)
North Canadian River Basin
Arkansas River Basin-Tulsa to Van Buren
Arkansas River Basin Van Buren to mouth
Lower Miss. River Basin-Yazoo River
South Canadian River Basin-above Texas-Oklahoma State Line
South Canadian River Basin-below Texas-Oklahoma State Line
Washita River Basin
Upper Red River Basin-above Denison
Lower Red River Basin-below Denison
Ouachita River Basin
Lower Miss. River Basin-Big Black River
Atchafalaya River Basin
Calcasieu River Basin
Lower Miss. River Basin-Natchez to Gulf
NUMBER OF MUNICIPAL PROJECTS REQUIRED
NUMBER OF MUNICIPALITIES WITH PROJECT REQUIREMENTS UNDETERMINED
NUMBER OF INDUSTRIAL PROJECTS REQUIRED
NUMBER OF INDUSTRIES WITH PROJECT REQUIREMENTS UNDETERMINED
SCALE OF MILES

SOUTHWEST-LOWER MISSISSIPPI
DRAINAGE BASINS
PROJECTS REQUIRED
FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO. 5

18d



SOUTHWEST–LOWER MISSISSIPPI
DRAINAGE BASINS
EXISTING PRIMARY WATER USES
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL
COLORADO
KANSAS
TEXAS
MISSOURI
ARKANSAS
MISS.
MEXICO

Although the data summarized are incomplete, and do not represent the progress in pollution abatement in some local areas within the basins, it emphasizes the need for continued early-action programs to promote the measures which are generally recognized.

On the basis of population to be served and per capita costs which appear reasonable for this region, it is estimated that the initial cost of needed municipal waste treatment plants will be approximately $50,000,000. This estimate includes projects for communities requiring new plants, complete replacement of existing plants and improvements or expansion of existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged to municipal sewers.

The lack of adequate data regarding the sources and amounts of industrial wastes discharging directly to the watercourses and the complexities in determining the type and magnitude of waste treatment facilities precludes an estimate of cost for needed industrial waste treatment facilities in the basins.

Table G. Requirements for municipal and industrial waste treatment plants*

Requirements**	Municipal		Industrial
	Number***	Population served by facilities	Number
New plant	132	929,600	43
Enlargement or additions to existing plant	251	1,279,900	20
Replace existing plant	134	435,100	1
No project required	289	2,007,500	42
Undetermined	40	309,100	975

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**For a listing of individual project needs refer to table I included at the end of each sub-basin discussion following the main part of this report.

***This number (846) includes two plants required by one municipality that is listed as one source of pollution.

Table H. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	149	35
Abatement ordered	2	—
Plans under preparation	28	8
Final plans approved	29	—
Construction awaiting financing	2	—
Under construction	25	1
Status undetermined	319	995

SUB-BASIN REPORTS

UPPER ARKANSAS RIVER SUB-BASIN
(Above Kansas-Colorado State Line)

Description

Geography--The Upper Arkansas River Sub-Basin embraces that portion of the Arkansas River Basin lying entirely within the State of Colorado and includes approximately 26,000 square miles within its drainage area. The stream arises in the high mountains in the vicinity of Leadville, Colo., at elevations in excess of 13,000 feet and flows for about 350 miles south and then southeast to the Colorado-Kansas line a few miles east of Holly, Colo.

The stream emerges from the mountains through the Royal Gorge at Canon City about 125 miles from its source and enters the great high plains area at Pueblo, which is about 40 miles below Canon City. A regulatory reservoir (John Martin) is located on the main stem just below its junction with the Purgatoire River. Major tributaries below Pueblo are Fountain Creek and the St. Charles, Huerfano, Apishapa, and Purgatoire Rivers. The largest contributor, in view of drainage area and runoff, is the Purgatoire River. The streams below Pueblo are used mainly for irrigation purposes.

Topography and Geology--About 17 percent of the drainage area is mountainous and extends above 8,000 feet altitude. About 45 percent of the area is at elevations from 5,000 to 8,000 feet and is mostly hilly except for small scattered tracts. The remaining 38 percent of this sub-basin lies between 3,500 and 5,000 feet elevation and consists of a fairly level plains region which is almost entirely used for agricultural purposes.

The geology in this portion of the Arkansas River is composed of two general classifications. The area above Canon City consists almost entirely of complex igneous and metamorphic rock of Pre-Cambrian and Tertiary age overlain in part by intrusive material, glacial moraine, and terrace deposits. Below Canon City and over the greater part of the eastern slope occur a series of sedimentary rocks. Probably the most important of these sedimentary beds is the Dakota Sandstone, which forms a large water bearing stratum underlying most of the lower part of the area.

Climate and Hydrologic Features--This sub-basin has two general types of climate. From the eastern edge of the region to the front range of the Rocky Mountains the climate is arid. The mountains have a subhumid climate. Variations are often extreme; the mean temperature difference between Lamar, Colo., and the top of Pikes Peak is about 35° F. The climate of the plains area is characterized by low humidity, reasonably long growing season, extreme daily and seasonal temperature ranges, little snow, frequent hail, and high rainfall intensity with the major portion of the annual precipitation occurring in the summer months.

In the mountainous regions, the climate is characterized by a decrease in mean temperatures with increased altitude, increased precipitation, less extreme temperature variations, and protracted cold spells.

Average annual precipitation in the area varies greatly with 11.67 inches at Pueblo, 16.05 inches at Lamar, and 18.63 inches at Leadville. Buena Vista has the lowest average precipitation with 8.78 inches per year. The major portion of the precipitation occurs during the growing season from April through October.

The mean annual temperatures vary from 35.6°F. at Leadville to 54.4°F. at Lamar. The average length of frost-free period varies from 83 days at Leadville to 173 days at Pueblo.

Maxima and minima stream flow data obtained at various gaging stations are shown in tabular form below:

Gaging station	Distance from mouth (miles)	Drainage area (square miles)	Stream flow (c. f. s.)	
			Maximum	Minimum
COLORADO				
Granite	1418.7	440	2,900	11
Salida	1375.0	1,200	5,100	124
Canon City	1322.3	3,050	19,000	82
Pueblo	1279.0	4,820	103,000	18
Nepesta	--	9,130	180,000	0
La Junta	1196.5	12,150	200,000	0
Las Animas	1175.0	14,530	23,600	8
Lamar	1135.6	19,470	165,000	0
Holly	1103.4	25,140	136,000	0

The runoff varies widely in the region with flows being greatly depleted in the plains area below Pueblo because of diversion for irrigation, channel absorption, and evaporation. The stream flow pattern in the upper Arkansas is such that the maximum stream flows occur in June, July, and sometimes August, following the snow-melt in the mountains. Streams are flashy and readily respond to intense rainfall on the upper tributaries. Low flows occur during the winter months from November through March and sometimes April. For purposes of stream flow analyses, low flow frequencies computed for summer and winter flow conditions are valuable aids. The demands of irrigation, together with return flows bring about little apparent relationships between stream flows at successive downstream stations and make accurate estimates of flow difficult except at established rated gaging stations. Flow at any point between gaging stations is problematical during the irrigation season. The operation of the recently completed John Martin reservoir near Lamar will probably serve to regulate stream flows in the Arkansas River below that point to some extent depending upon the irrigation demands and return flows above any given point under consideration.

The flow pattern of low winter flows and high summer flows brings about critical dilution problems in the winter with regard to water pollution control.

Economic Development

Population--The population in the sub-basin has increased steadily since 1880. Population in the headwaters area counties has decreased in later years because of the decline of mining in these regions. Counties and communities from Canon City and below have shown a general increase in population because of the steady development of agriculture and manufacturing in this area. In common with all other areas in the United States, there has been a marked increase in urban population and a decrease in rural population in the Upper Arkansas Sub-Basin after the turn of the century. The 1950 population of the sub-basin is estimated to be about 305,000, of which 60 percent is classified as urban and 40 percent as rural. This represents over a 10 percent increase since the 1940 census, when the population was 276,000, 55 percent being classified as urban and 45 percent as rural.

Industry and Land Use--The economy of the sub-basin is based upon agriculture, manufacturing, and mining. Agricultural pursuits, including stock raising, are the major activities in the region. Manufacturing is confined to the urban centers, principally at Pueblo where the major industry is the steel works, and at Leadville where a lead smelter is located. Mining is decreasing in importance and the overall activity in this field has declined in recent years as production costs have increased and the grade of ore reserves decreased. The minerals of the region, however, still make an important contribution to the national economy and security.

The major land use in the Upper Arkansas is for agricultural purposes including stock raising. There is an increasing recreational use being made of the mountainous region above Salida where hunting, fishing, skiing, and other sports are attracting increasing numbers of vacationers. Portions of Pike and San Isabel National Forests are in this region.

Use of Water Resources

Irrigation Use--The main water use in the sub-basin is for irrigation in the region below Pueblo, principally, and to a limited extent below Canon City. In the Arkansas River Valley in Colorado, irrigation has reached a high state of development. Normal stream flows of the main stem and its tributaries during the summer season are used entirely for irrigation purposes, as well as part of their flood and winter flows which are conserved in reservoirs. There are 23 major diversions between Canon City and the Colorado-Kansas line. Return flows in excess of 200,000 acre-feet annually reach the river channel between Pueblo and Holly for reuse by irrigation interests. About 500,000 acres of farm lands are irrigated annually in the sub-basin. The amount of land under irrigation has remained more or less static in recent years as it is dependent upon the available water supply which is developed to its maximum use. Diversion of additional water into the sub-basin from other sub-basins on the western slope of the Continental Divide is being considered.

The discharge of untreated sewage and other wastes into the streams during the irrigation season gives rise to problems in pollution abatement which, under other conditions, might not be considered as especially significant. Where sewage-polluted waters are applied to growing crops, the problem of possible dangers to the public health must be taken into consideration. The degree of such danger will depend upon the type of crop, the degree of pollution, the degree of sewage treatment provided, and the age of the pollution with regard to the time interval between discharge and use, among other factors. Maximum dangers occur when the time interval between discharge and reuse is short, no sewage treatment provided, irrigation is extensive, and the crops are of the low-growing type which could be eaten in the raw state and which would be harvested shortly after irrigation.

Domestic Use--There are 18 communities in the sub-basin which utilize surface waters for their domestic supplies. These supplies serve a total of approximately 155,000 persons with an average of 47 million gallons daily. Pueblo, the principal industrial center in the sub-basin, alone serves a population of 63,500 with an average of 24 million gallons daily, representing a per capita consumption of 380 gallons.

Ground water sources for domestic supplies are used by 38 communities to serve about 38,500 persons. The average daily consumption from these supplies is about 8.5 million gallons.

Pollution Data

The summaries of data available on sources and amounts of pollution originating within the Upper Arkansas River Sub-Basin, together with the kind of treatment installed or needed in the future, are shown in tables A_1 through I_1.

Table A_1 shows that 38 municipalities having a combined population of 171,800 discharge wastes into the Upper Arkansas River. Population equivalents of the total waste loads are not available.

Table B_1 shows that a total of 30 known industries discharge wastes into the streams of this sub-basin. No data are available as to the population equivalent of the 25 industries discharging organic wastes.

Table C_1 lists the type of treatment provided by municipalities discharging wastes into the Upper Arkansas. There are 20 communities (28 percent of contributing population) which discharge raw sewage into the streams, while 16 communities (68 percent of contributing population) provide for primary treatment and two communities (4 percent of contributing population) provide for secondary treatment of wastes before discharge into the streams.

Table D_1 lists the principal types of industries discharging wastes directly into the sub-basin streams. The only wastes receiving any type of treatment are those from some food and kindred products plants and one other mining industry. There are innumerable old tailings ponds located in the sub-basin which are continual sources of inorganic pollution from erosion. Control of these abandoned tailings piles is a problem as ownership cannot often be established. The number of plants shown under other mining industries is also subject to revision as there are many mines in the region which are worked intermittently or occasionally. Therefore, accurate enumeration of the number working at any given time is not easily determined. Further, coal mines operated in the vicinity of Trinidad have been omitted from the listing.

Table E_1 shows the adequacy of existing treatment plants. Of the 17 municipal treatment plants, eight are adequate from the standpoint of capacity, and only five of the plants are operated in a satisfactory manner.

Table F_1 shows available data on progress of pollution abatement in the sub-basin. One treatment plant was completed in 1947 and two in 1950. The Colorado State Department of Public Health is carrying on a rather intensive campaign of education and information with regard to stream pollution. The campaign has been well-received throughout the State, and it is quite probable that pollution abatement progress will be stimulated in the future as a result.

Table G_1 shows the requirements for municipal and industrial waste treatment plants on the Upper Arkansas River. The Colorado State Department of Public Health has recently endorsed a recommendation of its Water Pollution Control Advisory Committee that a minimum of primary sewage treatment shall be required for all domestic sewage discharged into streams of the State. This should also stimulate pollution abatement progress within the next few years.

Table H_1 shows data available as of July 1, 1950, on the status of treatment works projects to abate pollution.

Table I_1 shows the project list of municipalities and industries requiring improvements for abatement of pollution.

Table A_1. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	[1]21	17,300	13,500
Having population data available (Data on pollution load to watercourse incomplete or not available)	[2]17	154,500	—
Total	[3]38	171,800	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

**Includes industrial wastes discharged into municipal sewerage systems.

[1] Four sources do not reach watercourses, discharge to sub-surface disposal systems.

[2] Includes four municipalities with no existing sewerage systems — systems recommended by State Department of Public Health.

[3] Manitou included in total — dicharges to Colorado Springs plant.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Upper Arkansas River Sub-Basin will be approximately $3,500,000: This estimate is based on average construction costs considered reasonable for this State and includes needed sewerage facilities in addition to treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the many and varied kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table B₁. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	[1]25	Undetermined
Producing inorganic wastes	5	Not applicable
Producing wastes of undetermined type	1	Undetermined
Total	[2]30	—

*Industries having separate outlets discharging wastes directly into watercourse.

[1] Includes one plant also producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus,[1].

Table C₁. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	[1]16	15	116,500
Secondary	2	2	7,400
No treatment	[2]20	—	47,900

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

[1] Manitou sewage treated in Colorado Springs plant.

[2] Includes four municipalities having a population of 2,850 with no existing sewerage systems.

Table D₁. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	23	12	11	0
Rendering..................	1	0	1	0
Primary metals industries..	2	0	2	0
Other mining industries....	3	1	2	0
Santa Fe Railroad shops....	1	0	1	0
Total.................	30	13	17	0

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E$_1$. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	17	8	5	4	5	3	9
Industrial	13	—	4	9	—	4	9

Table F$_1$. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	0	—
1947	1	730	0	—
1948	0	—	0	—
1949	0	—	0	—
1950	2	2000	0	—

Table G$_1$. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	[1]20	47,900	1
Enlargement or additions to existing plant	2	61,200	2
Replace existing plant	3	3,400	—
No project required	4	2,300	—
Undetermined	[2]8	57,000	[3]27

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes new plants in 4 municipalities (pop. 2,850) with no existing sewerage systems.

[2] Includes 4 plants where existing units are of adequate capacity but which may require additional units to provide a higher degree of treatment.

[3] Includes 14 industries to be connected to municipal sewerage systems.

Table H$_1$. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	30	21
Abatement ordered	—	—
Plans under preparation	2	—
Final plans approved	1	—
Construction awaiting financing	—	—
Under construction	0	1
Status undetermined	—	8

Table I₁. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
COLORADO			
Municipalities:			
Aguilar	1,000	NP	Sewer system and plant recommended by Colorado Department of Public Health
Buena Vista	780	NP	do
Canon City	6,300	NP	—
Colorado Springs	53,000	Und.	—
Colorado State Penitentiary	1,300	NP	—
Cripple Creek	800	NP	—
Eads	1,000	Und.	—
East Canon	350	NP	—
Florence	2,500	NP	—
Fountain	710	NP	See remark for Aguilar
Fowler	1,000	NP	—
Granada	480	Und.	—
Holly	1,200	NP	—
Hugo	850	R	—
La Junta	7,300	NP	—
Lamar	7,700	NP	—
Las Animas	2,400	NP	—
LaVeta	700	Und.	—
Leadville	1,200	R	—
Limon	1,300	R	—
Manzanola	490	NP	—
Ordway	1,200	Und.	—
Pueblo	54,000	E-A	—
Rocky Ford	3,300.	NP	—
Rye	160	Und.	—
Salida	4,500	NP	—
South Canon	1,600	NP	—
Sugar City	420	Und.	—
Swink	330	NP	See remark for Aguilar
Trinidad	7,200	E-A	—
Victor	680	NP	—
Walsenburg	3,600	NP	—
Wiley	80	Und.	—
Industries:			
23 food and kindred products	—	13 MS, 2 E-A, 8 Und.	— —
1 rendering plant	—	1 MS	
1 railroad shop	—	1 Und.	—
2 primary metals industry	—	1 NP, 1 Und.	—
3 other mining industries	—	3 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
NP = New plant.
Und. = Undetermined.
R = Replacement of existing plant.
MS = Connect to municipal sewer system.

ARKANSAS RIVER BASIN
(Kansas-Colorado State Line to Tulsa, Oklahoma Sub-Basin)

Description

Geography--This portion of the Arkansas River Basin extends downstream from the Colorado-Kansas State line to Tulsa, Okla., and embraces about 30,400 square miles or about 19 percent of the total Arkansas River drainage area. The main stream emerges upon the plains of Kansas at an elevation of about 3,500 feet and flows generally in an easterly direction to Hutchinson, Kans. (elevation 1,515 feet) and then in a southeasterly direction to Tulsa, Okla. (elevation 655 feet), crossing the Kansas-Oklahoma State line near Arkansas City, Kans. The distance traversed is approximately 525 miles. There are few tributaries above Wichita, Kans., and practically no tributary flow west of Hutchinson. Tributaries below Hutchinson are Cow Creek and the Little Arkansas, Ninnescah, Walnut, Salt Fork, and Cimarron Rivers. The Cimarron River is the major tributary in this region. It is the subject of another sub-basin report and, therefore, not included in this discussion.

Topography--The stream from the Colorado-Kansas State line flows through an alluvial plain which is bounded on the north by steep bluffs and on the south by rolling sand hills. The stream above Hutchinson is characterized by broad sandy stream beds and low banks. Below Wichita the drainage area becomes broken and hilly.

Climate and Hydrologic Features--The mean annual temperature of the sub-basin below Hutchinson is about 57°F. with extreme temperature range of -15°F. to 115°F. Precipitation ranges from about 15 inches per year at Holly, Colo., to 37.5 inches per year at Tulsa. Although the rainfall increases generally from west to east, there is no similar accumulation of stream flow. The least flow in the Arkansas River is found in the vicinity of Hutchinson, Kans. Maximum flows of about 200,000 cubic feet per second above the Purgatoire River in Colorado decrease to about 7,500 cubic feet per second at Hutchinson, Kans. This is because of the absence of tributary flow in Western Kansas and the aggrading character of the river in this section and the absorption qualities of the area. There is a wide variation in runoff due to differences in rainfall, soil and topographic conditions. Silt and sand carriage by the river is considerable in this portion of the sub-basin.

Economic Development

Population--The 1950 population in the sub-basin is estimated to be about 706,500, of which 571,300 persons are in Kansas and 135,200 are in Oklahoma. In grazing areas the population density is as low as six per square mile. The principal cities, with populations, in the sub-basin are: Wichita - 111,000, Hutchinson - 27,000, Arkansas City - 14,000, El Dorado - 10,000, and Winfield - 9,000, all in Kansas; Ponca City - 16,000 and Blackwell - 9,500, in Oklahoma.

Industry and Land Use--The central plain area is the site of an extensive agricultural development. Wheat is the major crop in the western portion of the sub-basin and corn is the major crop in the east. Stock grazing is the dominant economic pursuit in the eastern and western margins of this sub-basin where the terrain is hilly and the soils are of inferior quality.

Production and refining of petroleum are major industrial activities in the sub-basin. Oil pools are found in both Kansas and Oklahoma. Refineries are located at Wichita, El Dorado, Garden City, Augusta, McPherson, Arkansas City, and Potwin in Kansas and at Ponca City, Blackwell, Kaw City, Shidler, and Cleveland in Oklahoma. Large salt mines are found at Hutchinson and Lyons, Kans. Extensive salt flats occur in central Kansas, particularly in Barton County, and near Cherokee, Okla. Gypsum is found over the entire sub-basin area.

Use of Water Resources

Along the northern portion of the sub-basin there are excellent sources of water at shallow depths, and underground water is generally plentiful throughout this sub-basin. The alluvial fill of the main valley, which is in general pervious, carries a large amount of water which moves down the valley almost as an underflow. At low stages of the streams much of the water sinks into the alluvial fill. Below Wichita the underground water becomes mineralized, mostly from contact with natural saline deposits. At some places this water is not suitable for human consumption.

None of the towns in this area in Kansas and very few of those in Oklahoma obtain their water supply from the streams which are contaminated with salt. Most of the urban water systems are supplied by underground water which is obtained at shallow depths and at a lower cost than is required to utilize surface sources. A few towns, especially in the southern portion, have impounded supplies, and the trend of improvement is in this direction. The recently completed Braman Reservoir on the Chicaskia River furnishes an impounded water supply for Blackwell, Okla. Rural water supplies are obtained in most places from shallow wells, commonly less than 100 feet deep. The water supplies of certain cities depending on ground water may be seriously impaired by the heavy demand required by air conditioning units. There is an urgent need of administrative control of water use for this purpose to insure against excessive depletion of the normal urban supply.

The majority of smaller industries and the large scale salt production works utilize ground water supplies predominantly. Oil refineries and natural gas industries use large volumes of both surface and ground waters for cooling purposes.

There are 15 surface water supplies serving a total of 91,000 persons and 123 ground water supplies serving 381,500 persons in the sub-basin area under consideration.

Pollution Data

Pollution in some of the watercourses of this sub-basin is acute, especially along the Walnut River in Kansas. The State Health Departments of both Kansas and Oklahoma have been cognizant of their pollution problems and are carrying on abatement programs to accomplish necessary treatment of municipal sewage before discharging into the watercourses.

In addition to the pollution from municipal sources, industrial wastes, especially those associated with the production and refining of petroleum, have posed a pollution problem of equal or greater significance in some local areas. The Walnut River is grossly polluted by brine and other wastes from oil production and refining operations. The Arkansas River is polluted by salt from commercial salt manufacturing and from natural salt deposits and to a lesser extent from oil field brines. Considerable reduction of stream pollution has been accomplished in both States by better production methods and waste disposal practices developed through cooperative efforts of the State agencies and oil producers.

The disposal of oil field brine waste, in some instances, has also created problems by polluting underground waters in or adjacent to certain oil fields. In some areas, water from underground sources is unfit for domestic use, as a result of pollution from this source.

Sheet erosion is serious in much of the agricultural portion of the area. In some sections the methods used in the production of wheat have contributed to this condition. Silting of many streams has resulted, and fish are now relatively scarce. However, the Soil Conservation Service is introducing contour farming, terracing, cover for fallow land, and discontinuance of the cultivation of the stream banks to help improve this condition.

The summaries of data available on sources and amount of pollution originating within the Arkansas River Basin extending from the Kansas-Colorado State Line to Tulsa, Okla. Sub-Basin, together with the kind of treatment installed or needed in the future, are shown in tables A_2 through I_2.

Table A_2 summarizes the pollution sources from municipalities in the sub-basin area under consideration. There are 94 municipalities serving a population of 421,800 discharging wastes into the sub-basin streams.

Table B_2 summarizes the pollution sources from industrial establishments discharging into the sub-basin watercourses. There are 18 such pollution sources.

Table C_2 lists the numbers of communities providing various kinds of treatment for their wastes before discharging into the watercourses. There are 26 communities (28 percent) serving about 77,500 persons discharging raw sewage into the sub-basin watercourses. Forty-nine communities (52 percent) serving a population of 120,700 provide for secondary treatment of the wastes discharged into the sub-basin streams. Nineteen communities (20 percent) provide primary treatment for their sewage before discharging into the streams.

Table D_2 summarizes the existing industrial waste treatment facilities in the sub-basin. Six of the 18 industrial plants discharging into the streams provide for some kind of treatment of their wastes before discharging into the streams.

Table E_2 summarizes the adequacy of the treatment plants now in the sub-basin. Of the 68 municipal plants, 27 (40 percent) are inadequate from the standpoint of capacity and 27 (40 percent) are inadequate as to operation. Of the six industrial waste treatment plants, four (67 percent) are inadequate as to capacity.

Table F_2 shows the progress made in pollution abatement during the period 1946 through 1949. Seven municipalities installed sewage treatment facilities.

Table G_2 summarizes the current requirements for municipal and industrial waste treatment plants. Of the 68 plants now in operation, 23 require enlargement or additions and six need replacements. Twenty-six new plants will be required in this sub-basin.

Table H_2 presents the status of treatment works projects as of July 1, 1950, for pollution abatement in the sub-basin. Of some 56 municipalities requiring projects for abatement of pollution, definite action is indicated in only eight cases.

Table I_2 shows the project list of municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Arkansas River Basin (Kansas-Colorado State Line to Tulsa, Okla. Sub-Basin) will be approximately $3,500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the varied kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_2. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	93	420,300	272,500
Having population data available (Data on pollution load to watercourse incomplete or not available)	1	1,500	—
Total	94	421,800	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_2. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	3	5,000
Producing organic wastes	11	Undetermined
Producing inorganic wastes	[1]15	—
Producing wastes of undetermined type	1	Undetermined
Total	[2]18	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes 12 plants also producing organic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

Table C_2. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	19	19	223,400
Secondary	49	49	120,700
No treatment	26	—	77,500

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D_2. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	3	—	—	3
Salt refining..............	3	0	3	0
Food and kindred products..	1	—	—	1
Miscellaneous..............	2	0	2	0
Products of petroleum and coal..................	9	6	—	3
Total..................	18	6	5	7

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_2. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	68	40	27	1	38	27	3
Industrial	6	2	4	0	6	0	0

Table F_2. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	1	4,000	No data	—
1947	3	—	do	—
1948	3	—	do	—
1949	0	0	do	—

Table G_2. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	26	77,500	4
Enlargement or additions to existing plant	[1]23	282,600	4
Replace existing plant	6	8,900	—
No project required	38	51,300	3
Undetermined	1	1,500	7

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes two plants where existing units are of satisfactory capacity but which require additional units to provide a higher degree of treatment.

Table H_2. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	12	—
Abatement ordered	1	—
Plans under preparation	2	—
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	5	—
Status undetermined	36	15

Table I$_2$. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
KANSAS			
Municipalities:			
Arkansas City	11,500	NP	—
Augusta	3,500	R	Under construction
Belle Plaine	800	NP	—
Buhler	520	E-A	—
Cheney	600	NP	—
Cimarron	770	NP	—
Deerfield	250	NP	—
Dodge City	7,500	E-A	—
Douglas	650	NP	—
El Dorado	9,000	E-A	—
Ellinwood	1,850	NP	—
Ft. Dodge	200	NP	—
Garden City	11,000	NP	—
Great Bend	8,000	NP	—
Gueda Springs	150	NP	—
Halstead	1,100	R	—
Hesston	300	E-A	—
Hutchinson	30,000	E-A	—
Kingsley	1,800	NP	—
Lakin	650	NP	—
Larned	3,200	NP	—
Lyons	3,500	E-A	—
McPherson	6,500	E-A	—
Medicine Lodge	1,300	E-A	—
Moundridge	700	E-A	—
Mulvane	1,000	NP	—
Newton	9,000	E-A	Under construction
Nickerson	850	NP	—
Oil Hill	500	NP	—
Oxford	850	NP	—
Pratt	6,500	E-A	—
St. John	1,500	R	—
Statford	1,500	Und.	—
Syracuse	1,100	NP	—
Towanda	250	NP	—
Tribune	400	E-A	—
Valley Center	600	E-A	—
Wichita	190,000	E-A	—
Industries:			
4 food and kindred products	—	1 Und, 3 NP	—
1 paper and allied products	—	1 NP	—
7 products of petroleum and coal:			
3 refineries	—	3 Und.	—
1 refinery	—	1 E-A	—
3 refineries	[1]5,000	3 E-A	—
OKLAHOMA			
Municipalities:			
Alva	4,900	NP	—
Billings	500	E-A	—
Blackwell	8,000	E-A	—
Braman	250	E-A	—
Burbank	250	R	—

See footnotes at end of table.

Table I₂. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950—Continued

Name	Population served	Project requirements**	Remarks
OKLAHOMA—Continued			
Cherokee	2,000	R	—
Cleveland	2,400	NP	—
Covington	560	E-A	—
Garber	800	E-A	—
Kaw City	600	R	—
Medford	1,100	E-A	—
Newkirk	2,100	E-A	—
Pawnee	2,600	E-A	—
Ponca City	15,000	NP	—
Pond Creek	850	E-A	—
Ralston	500	NP	—
Sand Springs	5,800	NP	—
Tonkawa	2,900	NP	—
Industries:			
3 oil production industries	—	3 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replace existing plant
Und. = Undetermined
NP = New plant
E-A = Enlargement or addition to existing plant

[1] Population equivalent.

VERDIGRIS RIVER SUB-BASIN

Description

Geography--The Verdigris River is a major tributary of the Arkansas River, entering the Arkansas near Muskogee, Okla. The stream is about 340 miles in length and arises in the Flint Hills in Lyons and Chase Counties, Kans. The stream flows in a southeasterly and then southerly direction through Kansas and Oklahoma to its junction with the Arkansas River. The drainage sub-basin covers an area of about 8,300 square miles. The stream has four principal tributaries which enter from the west. Two of these, the Fall and Elk rivers, lie entirely in Kansas. The largest tributary, the Caney River, flows through both Kansas and Oklahoma. The remaining major tributary, Bird Creek, lies entirely in Oklahoma.

Topography and Geology--The western boundary of the sub-basin is formed by the Flint Hills in Kansas and by the Osage Hills in Oklahoma. The terrain is rough and broken in these regions. The greater portion of the sub-basin lies on an undulating plain. The elevation at the source of the Verdigris River is about 1,350 feet which decreases to 669 feet at the Kansas-Oklahoma State line and to 450 feet at the mouth. The western highlands range in heights from 1,500 to 1,000 feet, which decrease rapidly to from 800 to 500 feet in the eastern plains area. The stream channel is well defined throughout its course; in Kansas the stream is winding with sharp bends, while in Oklahoma it consists of a series of wide bends connected by straight sections of channel. The geologic formations in the area are of sedimentary origin. Shell lime, hard limestone, blue shale, and limestone are the principal outcroppings. The water bearing stratum appears to be shale. The alluvial soil found in the river and creek bottoms is a heavy black loam which is resistant to erosion.

Climate and Hydrologic Features--The average annual precipitation over the sub-basin is 36 inches, varying from 31 inches near the headwaters to 39 inches near the Kansas-Oklahoma State line. Approximately 68 percent of the total rainfall occurs during the period from April to September. The climate is distinctly humid.

The average annual temperature in Kansas is 58°F., with a minimum average monthly temperature of about 34°F. and the maximum is 80°F.

During periods of low flow the stream is sluggish. Near the headwaters the slope is 3.7 ft. per mile, which decreases to 1.9 ft. per mile at the Kansas-Oklahoma State line.

At the Independence, Kans. gaging station, the mean monthly flow of the river was recorded as zero only once since 1921. This period of zero mean monthly flow lasted for a five-month period, from October through February, 1939-40. However, flows of over 5,000 cubic feet per second have been recorded at Independence, Kans., and over 16,000 cubic feet per second at Claremore, Okla. A flood control reservoir is located on the Fall River in Kansas and reservoirs have been proposed near Toronto and Neodesha on the Verdigris and near Elk City on the Elk River.

Economic Development

Population--The total 1950 population of the sub-basin is approximately 237,000. Of this number, about 127,000 are in Oklahoma and 110,000 are in Kansas. The principal communities in the sub-basin with their estimated populations are: in Kansas; Eureka - 3,500, Fredonia - 3,258, Neodesha - 3,716, Independence - 11,432, Coffeyville - 17,114, Cherryvale - 2,956, Caney City - 2,863, and Sedan - 1,635; in Oklahoma; Bartlesville - 19,262, Pawhuska - 5,307, Claremore - 5,530, Nowata - 3,972 and Wagoner - 4,400.

Industry and Land Use--The regional economy is based upon agriculture, oil production and refining, and lead and zinc smelting.

Principal agricultural pursuits are general farming, stock raising, dairying and the processing of farm products. The Flint and Osage Hills areas produce excellent pasturage. Principal agricultural crops are corn, hay, oats, forage crops, wheat and cotton.

Production and refining of petroleum is carried out on a large scale in both the Kansas and the Oklahoma portions of the sub-basin. The first discoveries in the mid-continent field were in this sub-basin. Strip mining of coal is carried out in Oklahoma.

Use of Water Resources

There are 29 surface water supplies in the Verdigris Sub-Basin serving an estimated 98,700 persons; 14 of these supplies are located in Kansas and the remaining 15 are in Oklahoma. Ground water supplies are utilized by 12 communities to serve a total of nearly 5,000 persons distributed in small population groups throughout the sub-basin.

Large quantities of surface water are utilized for industrial purposes, principally in the refining of petroleum. Inadequate supply in the Verdigris River, in Kansas during periods of low stream flows has made it necessary, at times, for some refineries to conserve and reuse their process water in order to maintain operations.

The river and its main tributaries are used very little for recreational activities other than hunting and fishing. However, a considerable amount of commercial fishing is done in the lower reaches of the river. Few of the choice game fish are found in any of the streams in the sub-basin.

Pollution Data

The main stem of the Verdigris River is not seriously polluted in Kansas by sewage and industrial wastes except below Coffeyville where there is a refinery waste pollution problem. The problem of oil field brine disposal is of special significance only on some tributary streams in Kansas. Years of abatement efforts have reduced the high chloride levels in many watercourses to acceptable limits.

The summary of data available on sources and amounts of pollution originating within the Verdigris drainage area, together with the kind of treatment installed or needed in the future is shown in tables A_3 through I_3.

Table A_3 summarizes the number of municipalities discharging sewage and other wastes into the sub-basin streams. A total of 28 communities serving an estimated 126,000 persons discharge into the watercourse in the sub-basin.

Table B_3 summarizes the industrial pollution contributed to the sub-basin streams. Six industrial plants discharge wastes into the streams.

Table C_3 summarizes the existing treatment facilities available in the sub-basin. Two communities (7 percent) serving an estimated 4,800 persons discharge untreated sewage into the streams; seven communities (25 percent) serving 9,400 persons provide for primary treatment of their wastes before discharge, and 19 communities (68 percent), serving 111,800 persons provide secondary treatment for their sewage before discharge into the streams.

Table D_3 indicates that of the six industrial plants listed as discharging wastes into the streams, four provide for some type of waste treatment prior to discharging them into the watercourses.

Table E_3 summarizes the adequacy of existing treatment facilities. Seventy percent of the existing municipal treatment plants are deemed inadequate from the standpoint of capacity, in addition to one-fourth of the industrial waste treatment plants. Over one-half of the municipal treatment plants do not provide for satisfactory operation.

Table F_3 shows the progress of pollution abatement in the Verdigris Sub-Basin for the period 1946 through 1949. Two municipal treatment plants serving 7,700 persons were constructed in 1948, and one industrial plant was constructed in 1949.

Table G_3 summarizes the requirements for municipal and industrial waste treatment plants in the Verdigris River Sub-Basin.

Table H_3 shows the status of treatment works projects to abate pollution as of July 1, 1950.

Table I_3 shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Verdigris River Sub-Basin will be approximately $2,500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

Table A_3. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	28	126,000	47,300
Having population data available (Data on pollution load to watercourse incomplete or not available)	—	—	—
Total	28	126,000	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B3. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	4	Undetermined
Producing inorganic wastes	[1]6	—
Producing wastes of undetermined type	0	—
Total	[2]6	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes 4 plants also producing organic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the several kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table C3. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	7	7	9,400
Secondary	[1]19	20	111,800
No treatment	2	—	4,800

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] Tulsa, Okla., employs two secondary treatment plants.

Table D3. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	2	—	—	2
Primary metal industries...	1	1	0	0
Chemical and allied products..................	1	1	0	0
Products of petroleum and coal......................	2	2	0	0
Total..................	6	4	0	2

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E3. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	27	8	19	0	12	15	0
Industrial	4	3	1	0	4	0	0

Table F₃. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	2	7,700	do	—
1949	—	—	1	—

Table G₃. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	2	4,800	—
Enlargement or additions to existing plant	10	94,600	1
Replace existing plant	9	9,100	—
No project required	8	17,500	3
Undetermined	0	0	2

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H₃. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	—	1
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	21	2

Table 13. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
KANSAS:			
Municipalities:			
Caney	2,200	NP	—
Cedarvale	750	R	—
Coffeyville	18,000	E-A	—
Elgin	170	E-A	—
Howard	800	R	—
Independence	11,000	E-A	—
Madison	800	R	—
Neodesha	2,800	E-A	—
Sedan	1,500	R	—
Industries:			
1 products of petroleum and coal	—	1 E-A	—
OKLAHOMA			
Municipalities:			
Avant	250	R	—
Barnsdall	1,500	R	—
Bartlesville	14,800	E-A	—
Claremore	4,000	E-A	—
Collinsville	1,800	R	—
Dewey	2,100	E-A	—
Hominy	2,600	NP	—
Pawhuska	5,000	E-A	—
Skiatook	1,300	R	—
Tulsa (Coal Creek Plant)	14,700	E-A	—
Tulsa (Flat Rock Creek Plant)	22,000	E-A	—
Wynona	400	R	—
Industries:			
2 oil production industries.	—	2 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.
E-A = Enlargement or addition to existing plant.

GRAND (NEOSHO) RIVER SUB-BASIN

Description

Geography--The Neosho River arises in the Flint Hills region in Morris County, Kansas, and flows in a generally southeasterly direction to near the town of Wyandotte in northeastern Oklahoma and its junction with the Spring River. The stream continues from this point as the Grand River and flows southeasterly to its junction with the Arkansas near Muskogee, Okla., about one-half mile below the mouth of the Verdigris River. The stream length is approximately 478 miles of which about 314 miles are in Kansas and the remainder in Oklahoma. The sub-basin embraces about 12,520 square miles of drainage area of which 50 percent (6,260 square miles) lies in Kansas, 23.5 percent (2,940 square miles) lies in Oklahoma, another 23.5 percent (2,940 square miles) lies in Missouri, and the remaining 3 percent (380 square miles) lies in Arkansas. The main tributaries are the Cottonwood River, Spring River, and Elk River.

Topography and Geology--The elevation at the stream source in the Flint Hills is 1,450 feet which decreases to 475 feet at the mouth. The stream has the peculiar characteristic of a flat slope in its middle reaches as far as the Kansas-Oklahoma line with an increased fall from there to the mouth. The headwaters areas are of a rolling prairie character with rock outcroppings which produce rough topography in places. The stream in its upper and middle reaches is very crooked but the stream bed is well defined with stable banks. The channel varies from 100 to 400 feet in width and is obstructed in the middle reach by numerous snags, wrack heaps and gravel bars. At low water, long stream stretches consist of a succession of pools and riffles.

The stream carries comparatively small amounts of silt. The banks are generally stable, varying in height from 15 to 30 feet and support a relatively good growth of timber and brush above the low water line.

The river valley varies in width from 1 to 4 miles. From the Cottonwood River confluence downstream to St. Paul, Kans., the watershed varies from 16 to 30 miles wide. Below that point the sub-basin broadens to about 90 miles wide near the Kansas-Oklahoma State line. In Kansas the Grand (Neosho) Sub-Basin is characterized by rolling uplands about 150 feet above and 1 to 5 miles from the river. These uplands have a rather steep slope, providing rapid runoff for the tributaries. Outcroppings of limestone, shales and some sandstone are found in Kansas. The Flint Hills, a predominant escarpment of flint-bearing limestone, runs north to south in the upper sub-basin region.

Climate and Hydrologic Features--The climate of the Grand (Neosho) River Sub-Basin is temperate and continental, being characterized by moderate winters and long warm summers. The mean annual temperature for the sub-basin is 57.4°F., with 76.4°F. and 35.9°F. as mean summer and winter temperatures respectively. Summer temperatures in the 100°F. range are common.

The mean annual precipitation over the sub-basin is about 40 inches, based on a 35-year period. This varies from 31 inches rainfall in the headwater area to about 45 inches in the lower region. The maximum yearly rainfall was 55.13 inches in 1947, and a minimum was 28.45 inches in 1936. About 65 percent of the precipitation occurs from April to September. Annual snowfall over the sub-basin averages about 12 inches. The maximum rainfall in the sub-basin occurs along the Elk River which drains the western slope of the Ozark Mountains.

Stream flows in the Grand River are rather erratic. Flash flood flows are common and long periods of low flow with periods of zero flow have been recorded at Iola and Parsons, Kans. The Grand (Neosho) River is one of the principal flood-producing tributaries of the Arkansas River. Although it comprises only about one-thirteenth of the total Arkansas River watershed, it produces about one-fourth of the major flood flows in the lower Arkansas River. The Kansas reach of the river watershed is subject to prolonged periods of low flow. This results from a combination of prolonged periods of low rainfall and excessive temperatures together with high evaporation and transpiration losses. Average and extreme flow conditions as recorded at various gaging stations are tabulated below:

Gaging station	Daily flow (c.f.s.)		
	Average	Maximum	Minimum
Iola, Kans.......	1,500	73,100	0
Parsons, Kans..........	2,500	83,500	0
Wagoner, Okla..........	11,300	400,000	54

Economic Development

Population--The 1950 population of the Grand (Neosho) River Sub-Basin is estimated at about 423,000, of which number about 38 percent live in Kansas, 36 percent in Missouri, 21 percent in Oklahoma, and 5 percent in Arkansas. The principal communities are: in Kansas, Pittsburgh - 19,371, Parsons - 14,706, Emporia - 15,560, Chanute - 10,241, Iola - 7,081, Galena - 4,019, Columbus - 3,473, Yates Center - 2,169, and Oswego - 1,990; in Missouri, Joplin - 38,515, Carthage - 11,150, Neosho - 5,780, and Mt. Vernon - 2,079; in Oklahoma, Miami - 11,703, Vinita - 5,501, Pryou - 4,441, and Picher - 3,923; and in Arkansas, Bentonville - 2,919.

Industry and Land Use--Agriculture is well established throughout the sub-basin. The principal crops are cereal grains and forage. The alluvial valley in Kansas is the most productive area but is subject to crop losses through floods. The area above Emporia is devoted to cattle raising and the Ozark region to orchards, vineyards and small fruits.

Petroleum and gas are found in the region about Chanute and Iola in Kansas and in Oklahoma.

The world's largest area of zinc and lead production is found in the Tri-State area of Kansas, Oklahoma, and Missouri centered about Joplin, Mo., and Baxter Springs, Kans. In the area about Pittsburg, Kans., strip coal mining operations are carried on producing large amounts of bituminous coal.

Principal industrial establishments are grain elevators, creameries, cheese plants, flour and feed mills, smelters, lead and paint works, cement plants and some meat packing and petroleum refining.

Use of Water Resources

Surface water supplies serving 22 communities with a combined population of 90,000 are found in the sub-basin. In general, ground waters are inadequate or unsuited for domestic use, except in the Ozark region. There are 66 ground water supplies listed in the sub-basin which serve an estimated 122,000 persons.

Many large industrial plants utilize several million gallons of water daily from both surface and ground water sources. The largest industrial water user in the sub-basin is the Spencer Chemical Company near Pittsburg, Kans., which draws over 40,000,000 gallons daily from company-owned wells and the Spring River.

The Ozark regions of the Spring and Elk Rivers are attractive for recreational purposes and are much used for game fishing.

A power development project has been constructed on the Spring River at Lowell, Kans. Reservoirs for flood control are being considered in areas above Iola and Council Grove and on the Cottonwood River above Marion, Kans., as well as along the Elk River.

Pollution Data

The main stem of the Neosho River in Kansas is not seriously polluted by sewage and industrial wastes. The problem of oil field brine disposal is of special significance only on some tributaries in Kansas. Years of abatement efforts have reduced the high chloride level in the river to generally acceptable limits. Mine drainage and oil refinery wastes also cause some local pollution problems in the sub-basin.

The summaries of data available on sources and amounts of pollution originating within the Grand (Neosho) River Sub-Basin, together with the kind of treatment installed or needed in the future, are shown in tables A_4 through I_4.

Table A_4 presents a summary of the sources of pollution of municipal origin. Forty-nine such sources are shown serving a population of 194,800.

Table B_4 summarizes the known sources of industrial waste pollution in the sub-basin. Five such sources are shown.

Table C_4 presents a summary of the existing waste treatment facilities in the sub-basin. Nine communities (19 percent) with a combined sewered population of 27,300 discharge untreated wastes to the sub-basin streams. Seven communities (14 percent) serving a combined population of 9,800 provide for primary treatment of their wastes before discharge into the streams. The remaining 33 communities (67 percent) serving a combined population of 157,700 provide secondary treatment of their wastes before discharging them into the basin watercourses.

Table D_4 summarizes treatment facilities provided for industrial wastes in the sub-basin. Treatment is provided at two industrial plants.

Table E_4 summarizes the adequacy of existing waste treatment plants in the Grand River Sub-Basin. Of the 42 existing municipal waste treatment plants, 22 (52 percent) are inadequate from the standpoint of plant capacity and 16 (38 percent) are inadequate as to operation. One industrial waste plant is inadequate as to capacity; operation is satisfactory.

Table F_4 summarizes the progress of pollution abatement in the sub-basin from 1946 through 1950. Two plants, to serve 20,300 persons, were placed in operation in the sub-basin during that period.

Table G_4 presents a summary of requirements for municipal and industrial waste treatment plants. Nine new municipal and two industrial waste plants are required. Enlargements are required by 13 municipal plant installations. Nine municipal waste treatment plants should be replaced.

Table H₄ shows the status of projects for pollution abatement works in the sub-basin as of July 1, 1950. Of some 31 projects required, definite action is indicated in only three cases.

Table I₄ shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Grand (Neosho) River Sub-Basin will be approximately $2,500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the several industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A₄. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	49	194,800	60,000
Having population data available (Data on pollution load to watercourse incomplete or not available)	--	--	--
Total	49	194,800	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B₄. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	3	Undetermined
Producing inorganic wastes	2	--
Producing wastes of undetermined type	--	--
Total	5	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Table C₄. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	7	7	9,800
Secondary	[1]33	35	157,700
No treatment	9	--	27,300

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] Joplin, Mo., and Columbus, Kans., each employ two secondary plants.

Table D_4. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	2	1	1	0
Distillery.................	1	0	1	0
Primary metal industries...	2	1	—	1
Total..................	5	2	2	1

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_4. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	42	20	22	0	26	16	0
Industrial	2	1	1	0	2	0	0

Table F_4. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	1	8,300	No data	--
1947	0	--	1	--
1948	0	—	—	--
1949	1	12,000	—	--
1950	—	—	1	—

Table G_4. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	9	27,200	2
Enlargement or additions to existing plant	13	58,500	—
Replace existing plant	9	32,600	—
No project required	20	76,500	2
Undetermined	0	—	1

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_4. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	6	—
Abatement ordered	1	—
Plans under preparation	2	—
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	22	3

Table 14. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
KANSAS			
Municipalities:			
Baxter Springs..............	4,500	NP	—
Burlington..................	2,000	E-A	—
Chanute.....................	9,000	NP	Planning
Chetopa.....................	1,500	NP	—
Cottonwood Falls............	750	E-A	—
Council Grove...............	2,300	R	—
Emporia (South).............	13,000	E-A	—
Erie........................	1,000	NP	—
Florence....................	950	R	—
Galena......................	3,800	NP	—
Iola........................	5,700	E-A	—
Oswego......................	2,800	R	—
Parsons.....................	13,000	E-A	Under construction
Peabody.....................	1,100	NP	—
Pittsburg...................	18,000	R	Planning
St. Paul....................	500	E-A	—
Industries:			
2 food and kindred products.	—	2 NP	—
1 primary metal industry....	—	1 Und.	—
MISSOURI:			
Municipalities:			
Carl Junction...............	500	NP	—
Carterville.................	1,200	NP	—
Carthage....................	8,000	E-A	—
Jasper......................	80	R	—
Sarcoxie....................	400	E-A	—
Webb City...................	4,500	NP	—
Industries:			
None reported...............	—	—	—
OKLAHOMA			
Municipalities:			
Afton.......................	1,000	R	—
Chelsea.....................	1,500	E-A	—
Commerce....................	2,000	R	—
Jay.........................	500	R	—
Picher......................	5,000	R	—
Pryor.......................	8,000	E-A	—
Quapaw......................	900	E-A	—
Vinita......................	4,300	E-A	—
Welch.......................	400	E-A	—
Industries:			
None reported...............	—	—	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replacement of existing plant.
Und. = Undetermined.
E-A = Enlargement or addition to existing plant.
NP = New plant.

WHITE RIVER SUB-BASIN

Description

Geography--The White River rises in the Boston Mountains in Northwestern Arkansas near Fayetteville and flows in a northerly direction into Missouri and then in an easterly direction through Southern Missouri for about 100 miles where it flows in a generally southeasterly direction returning to Arkansas and joins the Mississippi River about 45 miles above Arkansas City. The stream is approximately 640 miles in length and embraces a drainage area of 27,765 square miles. Its principal tributary is the Black River with a drainage area of 8,675 square miles which rises in the Ozarks and joins the White River near Newport, Ark. Other principal tributaries are the James, Buffalo Fork, North Fork, Little Red and Cache Rivers.

Topography and Geology--Approximately 75 percent of the drainage sub-basin of the White River and tributaries is situated in the Ozark highlands. The watershed is divided into the Ozark Highlands and the Mississippi embowment by a well-defined escarpment running in a general southeasterly direction from near Hodges Ferry, Mo. to the vicinity of Cabot, Ark. The Ozark region is formed by the Boston Mountains on the north and the Ozark Plateau on the south. The elevation of the White River at its source is about 1,800 feet. The stream drops an average of about four feet per mile to the vicinity of Batesville, Ark. and from there it drops about 0.36 feet per mile. The highlands range from moderately hilly to rugged topography. The major portion of the area is underlain by massive beds of limestone and dolomites which are honeycombed with caves. A thick bed of St. Peter sandstone throughout southeastern Missouri is sufficiently pure to use in glass production.

Climate and Hydrologic Features--Temperatures range from an annual average of 63°F. in the south to 58°F. in the north. Summer maxima average about 88°F Winters are generally cool and summers are long in the southern portion of the sub-basin.

The average annual precipitation ranges from 52 inches in the south to 44 inches in the northwest and 42 inches in the northern part of the sub-basin. Summer rains are often severe. The distribution of the rainfall is good for the growing season. Months of highest average rainfall are April, May, June, and January and those of the lowest average precipitation are February, October, November, and December.

Annual runoff averages about 16 inches. The streams in the upper sub-basin are swift and flow in deep narrow channels. Recorded average, maximum, and minimum stream flows at various gaging stations are tabulated below:

Gaging station	Daily flow (c.f.s.)		
	Average	Maximum	Minimum
ARKANSAS			
Beaver........	1,620	105,000	3
Batesville......	13,140	324,000	766
Black Rock*....	7,885	87,400	1,800
Newport.......	24,820	343,000	3,480

*On Black River.

Economic Development

Population--The 1950 population in the sub-basin is estimated to be 693,800. Principal communities in Arkansas and their populations are: Fayetteville - 17,024, Stuttgart - 7,094, Newport - 6,262, Searcy - 6,002, Batesville - 6,371, and Harrison - 5,545. Principal communities in Missouri are: Springfield - 66,302, Poplar Bluff - 15,120, West Plains - 4,923, Thayer - 1,632, and Doniphan - 1,612.

Industry and Land Use--Agriculture is the main occupation in the sub-basin. It is supplemented by manufacturing and mining. The best soils are found in the alluvial plain in the lower portion of the sub-basin. In the headwaters areas, the soils are poor and the rough terrain render the land unsuitable for farming. Orchards and small fruits and vegetables are grown in the uplands regions.

The Clark and Gardner and a portion of the Ozark National Forests lie within the upper sub-basin. The uplands regions are attractive as recreational areas and are being developed for this purpose. Many food processing plants including canneries and milk products plants are dispersed throughout the region. Glass and cement manufacturing and lumbering are carried on in the sub-basin especially in the highlands portion. Marble and limestone quarries are worked in southeastern Missouri, and glass sand is produced near Batesville, Ark. Lead, zinc, and manganese are mined in the sub-basin.

Use of Water Resources

There are 11 surface water supplies serving 51,400 persons located in this watershed.

Ground waters are extensive, plentiful and are of good quality. Sixty-three communities serving 159,300 persons utilize ground water supplies in the sub-basin. There is a large number of springs in the upper watershed some of which have very large capacities. There are seven in Missouri with daily flows in excess of 100,000,000 gallons.

Numerous food processing plants, including canneries, milk and milk products plants, utilize underground waters predominantly for sources of supplies. Extensive acreage in the Grand Prairie region of Arkansas used for the culture of rice is irrigated primarily from well supplies.

Power development is possible in the upland watershed area and investigations are being made to develop this natural resource.

Pollution Data

In the Ozark area there is pollution from small towns, camps and resorts as well as from small canneries and creameries. This pollution may jeopardize certain recreational developments and abatement should be considered for that use.

Summaries of data available on sources and amounts of pollution originating in the White River Sub-Basin, together with the kind of treatment installed or needed in the future are shown in tables A_5 through I_5.

Table A_5 summarizes the sources of municipal pollution in the sub-basin. There are 38 sewered communities serving about 132,700 persons.

Table B_5 shows the sources of industrial waste pollution in the sub-basin. Only one source is known.

Table C_5 shows the existing municipal treatment facilities in the sub-basin. Seven communities (18 percent) provide no treatment facilities for a population of 21,400. Twenty communities (51 percent) provide primary treatment for a sewered population of 28,200 and 12 communities (31 percent) serving 83,100 persons provide for secondary treatment.

Table D_5 shows that the status of the only known industrial plant in the sub-basin is undetermined as regards existing treatment facilities.

Table E_5 summarizes the adequacy of existing treatment plants. Of the 32 municipal treatment plants 20 or 62 percent were unsatisfactory in regard to capacity, and 20 or 62 percent were unsatisfactory in regard to operation. No data were available for industrial wastes treatment.

Table F_5 summarizes the progress in pollution abatement from 1946 - 1949. Three treatment plants to serve 22,000 persons were constructed in that period.

Table G_5 summarizes the requirements for municipal and industrial waste treatment plants in the White River Sub-Basin. Six new plants, nine enlargements, and nine replacements of existing municipal treatment plants are needed.

Table H_5 shows no data available as of July 1, 1950, on the status of treatment works projects to abate pollution.

Table I_5 shows the project list of municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the White River Sub-Basin will be approximately $2,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_5. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	36	132,700	57,100
Having population data available (Data on pollution load to watercourse incomplete or not available)	2	(1)	--
Total	38	132,700	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

[1] Population of two air bases unknown.

Table B_5. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	1	Undetermined
Producing inorganic wastes	—	—
Producing wastes of undetermined type	—	—
Total	1	—

*Industries having separate outlets and discharging wastes directly to watercourse.

Table C_5. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	20	20	28,200
Secondary	[1]12	12	83,100
No treatment	7	—	21,400

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] Includes one municipality with one primary and one secondary plant.

Table D_5. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products.	1	—	—	1
Total..................	1	—	—	1

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_5. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	32	12	20	0	12	20	0
Industrial	—	—	—	—	—	—	—

Table F_5. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	No data	--
1947	0	--	do	--
1948	2	10,000	do	--
1949	1	12,000	do	--

Table G_5. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	6	19,200	--
Enlargement or additions to existing plant	9	65,200	--
Replace existing plant	9	13,600	--
No project required	13	30,300	--
Undetermined	2	4,400	1

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_5. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	--	--
Abatement ordered	--	--
Plans under preparation	--	--
Final plans approved	--	--
Construction awaiting financing	--	--
Under construction	--	--
Status undetermined	26	1

Table I_5. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
ARKANSAS			
Municipalities:			
Bald Knob................	1,000	R	--
Batesville................	4,000	R	--
Beebe....................	700	R	--
Berryville................	850	E-A	--
Brinkley..................	2,300	E-A	--
Clarendon................	2,200	Und.	--
Clinton..................	150	E-A	--
Corning..................	500	NP	--
Cotton Plant............	800	R	--
DeWitt..................	2,200	Und.	--
Eureka Springs..........	2,200	E-A	--
Heber Springs............	1,100	E-A	--
Judsonia................	900	E-A	--
Kensett..................	350	R	--
Marvel..................	800	R	--
Newport #1..............	4,000	NP	--
East Plant..............	1,000	R	--
Pocahontas..............	2,500	NP	--
Searcy..................	4,200	E-A	--
Walnut Ridge............	1,500	NP	--
West Helena..............	4,500	R	--
Industries:			
1 food and kindred products................	--	1 Und.	--
MISSOURI			
Municipalities:			
Doniphan................	700	NP	--
Ozark....................	490	R	--
Poplar Bluff............	10,000	NP	--
Springfield (SW Plant)....	51,000	E-A	--
West Plains..............	2,500	E-A	--
Industries:			
None reported............	--	--	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**Und.= Undetermined.

R = Replacement of existing plant.

NP = New plant.

E-A = Enlargement or addition to existing plant.

LOWER MISSISSIPPI RIVER BASIN
(Cairo, Ill. to Helena, Ark. Sub-Basin)

Description

Geography--This sub-basin drains portions of five States bordering the Mississippi River and extends southward from Cairo, Ill. to Helena, Ark. The area includes portions of southeastern Missouri, southwestern Kentucky, western Tennessee, northeastern Arkansas and northwestern Mississippi. The main streams which are tributary to the reach of the Mississippi River in this sub-basin are the St. Francis, Castor, Whitewater, Obion, Forked Deer, Hatchie, and Wolf Rivers and Mayfield Creek. The drainage area covers approximately 20,800 square miles.

Topography and Geology--The sub-basin is divided into two distinct topographical areas; the upland regions on the east and in the headwaters area of the St. Francis River in Missouri, and the low alluvial lands along the Mississippi. Sandstone predominates in the Ozark area on the upper St. Francis. Memphis and Granada silt loams predominate in the eastern highland area together with Ruston sandy clay soil. The Mississippi plain contains rich alluvial soils. Marshy areas are common in the sub-basin.

Climate and Hydrologic Features--The climate is humid over these regions. The annual rainfall ranges from 47 to 52 inches per year and averages about 49 inches per year. Average temperatures are fairly high, averaging about 58°F. Summers are long with maximum temperatures of near 100°F. Winters are mild.

Stream flows in the region are variable. Flood flows may be from 150 to 430 times the low water flows. Streams tend to be sluggish in their lower reaches and flood crests are often sustained for relatively long periods. The following table shows average, maximum, and minimum flow data for various selected gaging stations:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
Mississippi River--Memphis, Tenn.	932,800	13	455,000	1,980,000	87,000
Obion River--Obion, Tenn.	1,800	18	2,180	99,500	249
North Fork of Obion River--Union City, Tenn.	490	18	564	49,200	89
South Fork of Obion River--Greenfield, Tenn.	431	18	511	25,600	85
South Fork of Forked Deer River--Jackson, Tenn.	574	18	705	35,800	80
South Fork of Forked Deer River--Chestnut Bluff, Tenn.	1,080	18	1,287	33,300	151
Hatchie River--Bolivar, Tenn.	1,430	18	2,229	50,000	162
Hatchie River--Stanton, Tenn.	1,940	18	2,816	59,000	229
Wolfe River--Rossville, Tenn.	531	18	652	31,000	141
St. Francis River--Patterson, Mo.	956	26	1,120	79,200	8
St. Francis River--Marked Tree, Ark.	—	13	3,644	48,300	0
Castor River--Zalma, Mo.	395	26	500	40,400	16

Economic Development

Population--According to the 1950 census, this sub-basin supports a population of about 1,539,700. Memphis, Tenn. is the largest city in the area with an estimated population of 394,012. Other of the large communities in Tennessee are: Jackson - 30,098, Dyersburg - 10,865, Humbolt - 7,435, and Brownsville - 4,659. The largest community in the Kentucky portion of the sub-basin is Mayfield - 8,508. Remaining communities in Kentucky are small. The major cities within the Arkansas portion of the sub-basin are: Blytheville - 16,221, Paragould - 9,660, West Memphis - 9,087, Forrest City - 7,591, Osceola - 5,005, Marianna - 4,525, and Wynne - 4,139. Corinth - 9,698 is the only large community in the Mississippi portion of the sub-basin. In the Missouri portion of the sub-basin the major communities are: Caruthersville - 8,578, Kennett - 8,678, Charleston - 5,500, and Fredericktown - 3,697.

Industry and Land Use--The region is predominantly rural in character and agriculture is the major activity. Most important products are cotton, corn, tobacco, and garden truck. There is also raising of hogs and cattle. Lumbering is carried on in the uplands regions. Large quantities of lead, limestone, and sandstone are mined in the upper St. Francis River Basin. The major manufacturing center is Memphis, Tenn., where a concentration of diversified industry is present and includes canning, textiles, milk, and milk products, wood processing, vegetable oil processing, chemicals, and paper products. Jackson, Tenn. is also a manufacturing center.

The region was at one time covered with extensive forests but most of the land has now been cleared. Malaria is a problem in certain areas within the sub-basin. Drainage is a prime necessity in the bottom lands in this area. Lands which cannot be reclaimed for use as farm land may be reserved for wildlife refuge areas and for water storage areas. Erosion of the highlands is serious.

Use of Water Resources

Nearly all of the domestic water supplies in the region are obtained from ground water sources. In the entire sub-basin area, there are 123 communities served by ground water supplies with an average of almost 66 million gallons daily. Only one community with a population of 1,300 is served from a surface source of water supply. The ground water supply in the area is abundant and is of good quality. Artesian waters are available in some sections of the sub-basin. All the industries in west Tennessee obtain their water supplies from wells.

There is game and commercial fishing in the largest streams and game fishing is possible in the headwaters streams. Recreational area developments are possible in the highland areas. Reelfoot Lake and Shelby Forest are utilized as recreational areas. Reelfoot Lake is also a wildlife refuge.

Pollution Data

Stream pollution is not a general problem. Water supplies are from ground water sources and discharge of sewage and industrial wastes into the streams has not as yet created nuisance conditions except in Wolf River at Memphis. Pollution problems are mostly of local importance.

Summaries of the data available on sources and amounts of pollution originating in this sub-basin, together with the kind of treatment existing or required in the future, are presented in tables A_6 through I_6.

Table A_6 shows the existing sources of pollution from communities in the sub-basin. There are 73 such sources serving an estimated 529,400 persons.

Table B_6 shows existing sources of industrial waste pollution in the sub-basin. Of the 40 known sources, 26 produce organic wastes with an estimated population equivalent of 741,600 persons.

Table C_6 summarizes the existing municipal treatment facilities. Twenty-four communities (33 percent) serving 405,600 persons discharge untreated wastes to the streams. Forty-one communities (56 percent) serving 93,200 persons provide primary treatment, and eight communities serving 30,600 persons provide secondary treatment for their wastes before discharge into the streams in the sub-basin.

Table D_6 summarizes the existing industrial waste treatment facilities. There are only two industrial waste treatment facilities reported.

Table A_6. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	55	468,500	601,000
Having population data available (Data on pollution load to watercourse incomplete or not available)	18	60,900	—
Total	73	529,400	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table E_6 summarizes the adequacy of existing waste treatment facilities. Of the 52 municipal treatment plants, 35 or 67 percent are unsatisfactory as to capacity and 14 or 27 percent are unsatisfactory as to operation. Two industrial waste treatment plants are unsatisfactory as to capacity.

Table F_6 summarizes pollution abatement progress in the sub-basin from 1946 through 1950. Some abatement progress was achieved during this period.

Table G_6 summarizes waste treatment plant requirements for the sub-basin. Municipal requirements include 19 new plants, 21 enlargements of existing plants and 15 replacements to serve 388,100, 54,300, and 38,500 persons, respectively. Industrial waste treatment requirements are for 23 new plants, one enlargement and one replacement; 12 are undetermined.

Table B_6. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	[1]26	741,600
Producing organic wastes	9	Undetermined
Producing inorganic wastes	4	--
Producing wastes of undetermined type	4	Undetermined
Total	[2]40	--

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes three plants also listed as producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus,[1].

Table H_6 shows the data available as of July 1, 1950, on the status of treatment works projects to abate pollution.

Table I_6 shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Lower Mississippi River Basin (Cairo, Ill., to Helena, Ark. Sub-Basin) will be approximately $5,500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the many and varied kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table C_6. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	[1]41	44	93,200
Secondary	8	8	30,600
No treatment	24	--	405,600

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] One municipality has three plants and one has two plants.

Table D_6. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having: Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products	23	--	15	8
Chemical and allied products	3	0	3	0
Rubber products	1	0	1	0
Leather and leather products	1	1	0	0
Miscellaneous	7	1	5	1
Textile mill products	3	--	1	2
Products of petroleum and coal	2	--	1	1
Total	40	2	26	12

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_6. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to: Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	52	17	35	0	38	14	0
Industrial	2	0	2	0	2	0	0

Table F_6. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	1	1,500
1947	0	--	2	19,500
1948	0	--	2	57,000
1949	0	--	0	0
1950	1	13,000	0	0

Table G_6. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	19	388,100	23
Enlargement or additions to existing plant	[1]21	54,300	1
Replace existing plant	15	38,500	1
No project required	16	34,600	3
Undetermined	[2]5	13,900	12

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes one plant having satisfactory capacity but which requires additions or enlargement to provide a higher degree of treatment.

[2] Includes three plants having satisfactory capacity but project needs to provide a higher degree of treatment are as yet undetermined.

Table H_6. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	13	14
Abatement ordered	—	—
Plans under preparation	—	4
Final plans approved	8	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	39	19

Table I_4. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
ARKANSAS			
Municipalities:			
Blytheville No.1............	5,700	R	—
No.2............	1,700	R	—
No.3............	2,100	R	—
Earle..........................	1,500	NP	—
Harrisburg....................	1,500	E-A	—
Helena.........................	8,000	Und.	—
Hughes.........................	1,000	E-A	—
Lepanto........................	2,000	NP	—
Marianna.......................	3,000	NP	Plans approved
Osceola........................	2,100	R	—
Paragould......................	9,000	E-A	—
Parkin.........................	700	Und.	—
Piggott........................	2,000	NP	—
Rector.........................	1,000	R	—
Tyronza........................	600	R	—
West Memphis...................	2,500	Und.	—
Wilson.........................	2,000	R	—
Wynne..........................	2,500	NP	—
Industries:			
None reported................	—	—	—
KENTUCKY			
Municipalities:			
Clinton........................	500	NP	—
Fulton.........................	3,000	R	—
Hickman........................	2,000	NP	—
Mayfield.......................	7,000	R	—
Industries:			
5 food and kindred products.	—	5 NP	—
2 textile mill products.....	—	2 NP	—
MISSISSIPPI			
Municipalities:			
Corinth........................	5,000	E-A	—
Industries:			
2 food and kindred products.	—	2 Und.	—
MISSOURI			
Municipalities:			
Campbell.......................	1,100	E-A	—
Chaffee........................	1,500	R	—
Charleston.....................	3,000	R	—
Dexter.........................	2,100	E-A	—
East Prairie...................	1,000	E-A	—
Farmington.....................	3,000	E-A	—
Fredrickstown..................	2,600	E-A	—
Kennett........................	2,060	E-A	—
Malden.........................	2,000	E-A	—
Portageville...................	630	E-A	—
Sikeston East Plant..........	3,500	E-A	—
West Plant.........	1,500	E-A	—
Steele.........................	1,200	NP	—
Senath.........................	800	E-A	—
Industries:			
None reported................	—	—	—

See footnotes at end of table.

Table I_4. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served	Project requirements**	Remarks
TENNESSEE			
Municipalities:			
Bemis	600	NP	—
Bolivar	1,100	E-A	—
Covington	3,200	E-A	—
Dresden	1,800	Und.	—
Dyersburg	9,900	NP	—
Gleason	200	NP	—
Henderson	1,600	R	—
Humboldt	3,900	NP	—
Jackson	21,000	NP	—
Martin	4,100	E-A	—
McKenzie	2,100	E-A	—
Memphis	300,000	NP	—
Milan	4,000	E-A	—
Obion	150	NP	—
Ridgely	850	NP	—
Ripley	1,900	R	—
Selmer	900	Und.	—
Somerville	850	R	—
South Fulton	2,900	E-A	—
Tiptonville	1,100	NP	—
Trenton	3,200	NP	—
Union City	4,500	R	—
Western St. Hospital	2,500	NP	—
Industries:			
14 food and kindred products	[1]364,500	10 NP, 4 Und.	—
1 textile mill products	[1]16,000	1 Und.	—
2 products of petroleum and coal	[1]1,700	2 Und.	—
4 chemical and allied products	[1]94,500	1 Und., 3 NP	—
1 rubber products	[1]120,500	1 NP	—
1 leather and leather products	[1]6,500	1 E-A	—
5 miscellaneous	[1]139,300	3 NP, 2 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replacement of existing plant
NP = New plant
Und. = Undetermined
E-A = Enlargement or addition to existing plant

[1] Population equivalent

CIMARRON RIVER SUB-BASIN
(New Mexico, Colorado, Kansas and Oklahoma)

Description

Geography.--The Cimarron River, a major tributary of the Arkansas River, rises in the Raton Mountains in northeastern New Mexico and flows eastward into Oklahoma, entering the State near Kenton. The stream continues eastward across Cimarron County to near Boise City where the river turns northeasterly crossing the southeast corner of Colorado and the southwest corner of Kansas to a point near Satanta, Kans. where the river turns in a southeasterly direction and enters Oklahoma again in Beaver County. It crosses Beaver County and enters Kansas a second time. Turning southeasterly, the Cimarron enters Oklahoma for the third time and continues to flow in a southeasterly direction across the State to a point near Guthrie where it turns northeasterly and continues to its junction with the Arkansas River about 17 miles above Tulsa, Okla. The stream is approximately 600 miles in length and has a drainage area of about 19,000 square miles, of which 1,150 are in New Mexico; 2,100 are in Colorado; 6,450 are in Kansas and 9,300 are in Oklahoma. The principal tributary is the North Fork which rises in Colorado and joins the Cimarron near Satanta, Kans. Other important tributaries are Crooked, Buff, Buffalo, Eagle Chief, Turkey, Kingfisher, Cottonwood, Ephraim and Stillwater Creeks. The stream carries a reddish sediment which gives it a characteristic color.

Topography and Geology.--The headwaters of the Cimarron River drain mountains and plateaus in New Mexico with a maximum altitude of 8,000 feet. The altitude at the New Mexico-Oklahoma line is 4,600 feet. In New Mexico the river flows in a narrow canyon eroded in the sandstones, but in places wider valleys appear, affording some tillable land.

In Oklahoma, the canyon widens into a valley about two miles in width. This valley is about 60 miles long. At its lower end the river channel narrows to that of a small dry creek, with no indication that flood conditions ever appear. It retains this form for another 60 miles, after which springs appear and the river takes on a new appearance. This dry stretch marks the division between the upper and lower rivers. Little water passes this reach, except in periods of extreme flood conditions. The topography is broken and rough. The lower 250 miles of the river is sandy and broad, in places a mile or more in width. For more than 50 miles sand hills are covered with scrub oak along the stream. At certain points deep ravines have been cut in the red beds.

Climate and Hydrology.--The western portion of the sub-basin is semiarid and is characterized by low relative humidity, wide temperature changes, cool winters, hot summers, and poor rainfall distribution. The lower third of the sub-basin has a typical humid climate and better rainfall distribution. Precipitation in the headwaters area is about 18.5 inches annually; there is a general increase eastward to the mouth of the river where the annual average is about 37 inches. There is sufficient moisture in the lower third of the sub-basin to support successful farming without irrigation.

Most of the tributaries of the Cimarron River are dry creeks except during torrential rains. Except for the North Fork, they are short with small drainage areas. The runoff characteristics of the Cimarron River are peculiar because of the variable physiographic and climatic conditions encountered in the sub-basin. The upper portion of the watershed from the source to Arkalon, Kans. (240 miles) contains the headwaters area where the stream flows are those of a typical flashy mountain stream. The summer flows are utilized for irrigation. Flows originating in the headwaters are dissipated in the wide sandy stream bed below Kenton, Okla. Stream flows in the central portion of the Cimarron watershed extending from Arkalon, Kans. to Kingfisher, Okla. (220 miles), in some respects are similar to those in the upper portion of the watershed. The first hundred miles of this section are characterized by rapid runoff from a rough and broken watershed. Many of the larger tributaries enter in this stretch. Stream flows are erratic and are rapidly dissipated in the wide, sandy stream channel of the main river which is often dry for weeks at a time.

The lowest section of the river from Kingfisher, Okla. to the mouth (140 miles) is the principal flood producing area. Rainfall is heavier and more frequent in this area and the stream channel is narrow and well defined.

Recorded average, maximum and minimum stream flows at various gaging stations are tabulated as follows:

Gaging station	Daily flow (c.f.s.)		
	Average	Maximum	Minimum
OKLAHOMA			
Boise City.....	20	80,000	0
Mocane........	100	9,600	0
Waynoka.......	466	--	0
Guthrie........	1,000	46,000	0.1
Perkins........	1,400	55,700	1.0

Economic Development

Population. --The 1950 population of the sub-basin is approximately 217,400, about 70 percent of which is in Oklahoma. The principal cities are Guthrie - 10,019, Enid - 35,976, Stillwater - 20,155, Cushing - 8,396, Drumright - 5,015, and Kingfisher - 3,350, all of which are in Oklahoma.

Industry and Land Use. --Farming is the principal occupation in the sub-basin. The type of farming varies from irrigation in New Mexico, to dry farming from there eastward to the 99th meridian, and to normal farming east of the 99th meridian. The best farm lands in the sub-basin lie in the lower 200 miles, especially below Fairview, Okla. This region is adapted to the growing of small grains, alfalfa, corn, and cotton. Cattle raising is the major agricultural activity in the western portion of the sub-basin.

The eastern portion of the sub-basin contains extensive oil and gas fields. One of the largest gas fields in the country (the Hugoton) crosses the sub-basin.

Use of Water Resources

Three communities serving 39,700 persons utilize surface water supplies in this sub-basin. Water supply is not an acute problem. Most communities have satisfactory supplies obtained from underground sources. There are 60 such supplies serving 81,320 persons in the sub-basin. In two Oklahoma counties, the water supply is soft; in part of the Kansas area the water is quite hard but otherwise satisfactory. Drought conditions seriously affect rural supplies obtained from shallow wells.

In the eastern portion of the sub-basin all of the available stream flow in the summer is used for irrigation purposes.

Pollution Data

Stream pollution is serious in the eastern end of the sub-basin. Very little sewage is discharged into the Cimarron River above Fairview, which is 200 miles from the mouth of the river. Guthrie, with a population of 10,019 is the largest of two communities discharging untreated sewage. This source of pollution is 120 miles from the mouth of the river. At periods of low flow the discharge of untreated sewage creates objectionable conditions in the lower reach of the river. These are aggravated by wastes from the oil fields. A number of towns and cities in the sub-basin need sewerage improvement projects.

Silting is a serious problem in this region, but damage to reservoirs can be reduced by proper soil conservation methods.

Summaries of the sources and amount of pollution originating in the Cimarron drainage sub-basin, together with the kind of treatment existing or required, are presented in tables A_7 through I_7.

Table A_7 shows that there are a total of 33 communities serving an estimated population of 92,000 discharging wastes into the streams of the sub-basin.

Table B_7 lists the industrial waste pollution sources in the sub-basin. There are four such sources producing organic wastes. Data regarding industries in general are not available.

Table C_7 summarizes the municipal treatment facilities existing in the sub-basin. Two communities (6 percent) serving 13,500 persons discharge raw sewage into the sub-basin streams. Seven communities (21 percent) serving 5,500 persons provide for primary treatment for their wastes and 24 communities (73 percent) serving 73,000 persons provide secondary treatment for their wastes before discharge into the sub-basin streams.

Table D_7 shows existing industrial waste treatment facilities in the sub-basin. No data are available as to treatment provided.

Table E_7 summarizes the adequacy of existing municipal and industrial waste treatment plants. Of the 31 municipal plants, 13, or less than half, are unsatisfactory as to capacity and 11 (35 percent) are unsatisfactory as to operation. There are no data on industrial plants.

Table F_7 summarizes progress made in pollution abatement in the Cimarron Sub-Basin from 1946 through 1950. During this period nine municipal plants to serve a population of 37,800 have been placed in operation.

Table G_7 shows the treatment plant requirements for municipal and industrial wastes. A total of 8 enlargements, two new plants, and five replacements of existing plants are required for municipal installations. There are 129 industrial sources of pollution with project requirements undetermined.

Table H_7 summarizes the status of pollution abatement works projects in the sub-basin as of July 1, 1950. Plans have been approved for two municipal projects and are underway for three others. No data are available on the status of industrial wastes treatment projects.

Table I_7 shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Cimarron River Sub-Basin will be approximately $2,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the many unclassified industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_7. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	30	85,100	34,300
Having population data available (Data on pollution load to watercourse incomplete or not available)	3	6,900	--
Total	33	92,000	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_7. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	[1]4	Undetermined
Producing inorganic wastes	[1]4	--
Producing wastes of undetermined type	125	Undetermined
Total	[2]129	--

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Represents four sources producing both organic and inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus,[1].

Table C_7. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	7	7	5,500
Secondary	24	24	73,000
No treatment	2	--	13,500

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D_7. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	4	--	--	4
Not classified.............	125	--	--	125
Total.................	129	--	--	129

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_7. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	31	18	13	0	18	11	2
Industrial			(No Data Available)				

Table F_7. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	1	1,000	No data	--
1947	0	--	do	--
1948	4	26,300	do	--
1949	3	5,500	do	--
1950	1	5,000	do	--

Table G_7. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	2	13,500	--
Enlargement or additions to existing plant	8	55,100	--
Replace existing plant	5	5,100	--
No project required	18	18,300	--
Undetermined	0	--	129

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_7. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	8	--
Abatement ordered	0	--
Plans under preparation	3	--
Final plans approved	2	--
Construction awaiting financing	0	--
Under construction	2	--
Status undetermined	0	129

Table I_7. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
KANSAS			
Municipalities:			
None reported	--	--	--
Industries:			
None reported	--	--	--
OKLAHOMA:			
Municipalities:			
Bethany	2,600	E-A	--
Britton	3,400	E-A	--
Cushing	6,000	E-A	--
Drumright	3,900	NP	--
Edmond	4,000	E-A	--
Enid	26,400	E-A	--
Guthrie	9,600	NP	--
Hennessey	1,300	R	--
Jennings	300	R	--
Kingfisher	2,700	E-A	--
Okeene	1,000	E-A	--
Oilton	1,000	R	--
Stillwater	9,000	E-A	--
Waynoka	1,300	R	--
Yale	1,200	R	--
Industries:			
4 oil production industry	--	4 Und.	--
125 not classified industry	--	125 Und.	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R =Replacement of existing plant.
Und =Undetermined.
NP =New plant.
E-A =Enlargement or addition to existing plant.

NORTH CANADIAN RIVER SUB-BASIN

Description

Geography.--The North Canadian River is formed by the junction of Corrumpa and Seneca creeks in Cimarron County, Oklahoma. These creeks arise in the high plateau region of northeastern New Mexico. The stream flows in a generally easterly direction from its source to a point near Woodward, Okla., where it turns in a southeasterly direction and continues across central Oklahoma to its junction with the South Canadian River near Eufaula, Okla., in the eastern part of the State. The river has a total length of about 800 miles and its drainage area embraces 17,870 square miles of which 920 are in New Mexico, 4,850 are in Texas and 12,100 are in Oklahoma. Above Fort Supply the stream is known generally as the "Beaver River."

The principal tributaries of the North Canadian River are: Coldwater, Paloduro, Kiowa, Wolf, Persimmon, Wewoka, and Deep Fork Creeks. Deep Fork is the most important tributary with a drainage area of 2,500 square miles and a length of 235 miles.

Topography and Geology.--The North Canadian headwaters are at an elevation of about 6,500 feet. This decreases to about 4,600 feet at the New Mexico line, to 3,080 feet at Guymon, to 1,863 feet at Woodward, to 1,306 feet at El Reno and to 500 feet at the mouth. The headwaters region is characterized by rolling prairie and well defined drainage. From the New Mexico-Oklahoma line eastward to the 100th meridian, the stream flows through a sandy region characterized by intermittent flow in certain stretches especially above Coldwater and Paloduro creeks and again above Wolf Creek. East of the 100th meridian the sub-basin narrows rapidly from 50 to 12 or 15 miles and maintains this width for about 100 miles and from there it expands into a crude oval about 60 by 100 miles near Oklahoma City. Above Oklahoma City the stream channel changes from shallow to deep. Below Oklahoma City the topography is rolling and the drainage channels are well defined. The valley narrows near the mouth of the river.

Climate and Hydrologic Features.--Climatic conditions in the sub-basin vary from semiarid to humid. Annual average temperatures are about 59°F. The precipitation ranges from an annual average of about 18 inches in the west to about 41 inches in the eastern portion of the sub-basin. The rainfall increases at a fairly uniform rate from west to east. Most of the precipitation occurs during the period from May through September but is more evenly distributed in the far eastern portion of the sub-basin.

Stream flow in the upper portion of the sub-basin is erratic. Zero flows are common in that portion of the stream in the Oklahoma Panhandle. The tributaries are mostly perennial streams.

The average, maximum, and minimum stream flows for selected gaging stations are tabulated as follows:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
OKLAHOMA					
Near Guymon.....	2,040	9	--	44,000	0
Beaver....	7,210	9	--	70,000	0
Ft. Supply......	8,920	10	151	50,000	0
Woodward....	10,680	9	--	42,000	0
Canton....	11,600	10	273	24,800	0
El Reno....	12,100	12	277	15,000	0
Oklahoma City.....	12,400	9	--	16,700	12
Wetumka...	13,500	9	--	66,000	26

Economic Development

Population.--There are no large centers of population in the New Mexico or Texas portions of the drainage area. The 1950 population in the sub-basin area is approximately 564,000. The principal population centers all in Oklahoma are: Oklahoma City - 242,450, Shawnee - 24,457, El Reno - 10,971, Wewoka - 6,753, Woodward - 5,896, Guymon - 4,704, Watonga - 3,238 and Wetumka - 2,012.

Industry and Land Use.--Agriculture is developed throughout the sub-basin. West of the 99th meridian, irrigation is important where an area in excess of 10,000 acres is under irrigation. The best soils are found in Canadian County, Oklahoma, but most intensive cropping is in the vicinity of Oklahoma City. Major crops are wheat, corn, oats, barley, grain sorghums and forage. Livestock raising is an important related activity. Major industrial activity in the sub-basin is that of production and processing of petroleum and natural gas. Oklahoma City is the major industrial area.

Use of Water Resources

There are 13 surface water supplies in the sub-basin serving about 279,000 persons, and 55 ground water supplies serving about 88,500 persons. Water supplies are known to be inadequate in many communities. The largest and most important supply is that of Oklahoma City which is taken from the main stem of the North Canadian River.

Drought conditions seriously affect the ground water supply in rural areas.

Irrigation needs are in excess of the available surface water supplies. Fort Supply Reservoir on Wolf Creek is utilized for irrigation in the vicinity of Woodward, Okla. Stream regulation is needed to supply water for all needs. Silting is a serious factor in reservoir capacity in this region as erosion is widespread.

Pollution Data

Stream pollution is of importance in the lower end of the sub-basin. Communities and industries discharge considerable amounts of wastes into the streams. Salt brine and waste oils from oil production operations further aggravate the conditions.

Summaries of available data on the sources and amounts of pollution originating in the North Canadian River Sub-Basin, together with the kind of treatment installed or needed in the future are presented in tables A_8 through I_8.

Table A_8 shows that there are 52 municipalities serving an estimated 449,700 persons discharging wastes into the watershed streams.

Table B_8 lists sources of industrial waste pollution in the sub-basin. There are four installations discharging wastes of known type to the streams. The types of wastes produced at 319 other sources are undetermined.

Table C_8 summarizes the existing municipal treatment facilities in the sub-basin. There are four communities (8 percent) serving 29,500 persons discharging untreated wastes into the streams. Thirteen communities (25 percent) serving 110,700 persons provide primary treatment for their wastes and 36 communities (67 percent) serving 309,500 persons provide for secondary treatment of their wastes before discharge into the streams in the sub-basin.

Table D_8 summarizes existing industrial waste treatment facilities in the sub-basin. Little or no data are available with regard to these facilities.

Table E_8 shows the status of existing waste treatment facilities in the North Canadian River Sub-Basin. Of the 49 municipal treatment plants, 33 or 67 percent are inadequate as to capacity and 16 or 33 percent are unsatisfactory as to operation. No data are available for industrial wastes treatment plants.

Table F_8 shows the progress of pollution abatement in the sub-basin during the period 1946 through 1949. There were four municipal treatment plants serving 9,200 persons placed in operation during that period.

Table G_8 summarizes the requirements for waste treatment plants in the sub-basin. New plants are required by six communities serving 31,400 persons; enlargements are required of 28 plants serving 175,800 persons and replacements are required for four communities serving 7,100 persons. No data are available for industrial waste treatment requirements.

Table H_8 summarizes the status of treatment works projects as of July 1, 1950. Four municipalities have plants under consideration, one has plans approved, one is awaiting financing, and four have plants under construction. No data are available for industry.

Table I_8 shows the project list for municipalities and industries requiring improvements for abatement of pollution.

Table A_8. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	50	446,200	188,800
Having population data available (Data on pollution load to watercourse incomplete or not available)	2	3,500	—
Total	52	449,700	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

It is estimated that the initial cost of needed municipal waste treatment facilities in the North Canadian River Sub-Basin will be approximately $4,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the several industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table B_8. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	[1]4	Undetermined
Producing inorganic wastes	[1]4	—
Producing wastes of undetermined type	319	Undetermined
Total	[2]323	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Represents four sources producing both organic and inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus,[1].

Table C_8. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*[1]	Plants	
Primary	13	13	110,700
Secondary	36	36	309,500
No treatment	4	—	29,500

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] Oklahoma City has two plants, one primary and one secondary.

Table D_8. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	4	—	—	4
Not classified.............	319	—	—	319
Total..................	323	—	—	323

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_8. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	49	16	33	0	33	16	0
Industrial			(No data available)				

Table F_8. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	4	9,200	do	—
1948	0	—	do	—
1949	0	—	do	—

Table G_8. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	[1]6	31,400	—
Enlargement or additions to existing plant	[2]28	175,800	—
Replace existing plant	4	7,100	—
No project required	15	235,400	—
Undetermined	0	—	323

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes 2 existing treatment facilities which due to local conditions have been classified as needing new plants rather than replacements.

[2] Includes one plant where existing treatment units have adequate capacity but which requires enlargement or additions to provide a higher degree of treatment.

Table H_8. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	19	—
Abatement ordered	—	—
Plans under preparation	4	—
Final plans approved	1	—
Construction awaiting financing	1	—
Under construction	4	—
Status undetermined	6	323

Table I_8. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
OKLAHOMA:			
Municipalities:			
Beaver	1,000	E-A	—
Boise City	900	R	—
Bristow	5,500	E-A	—
Britton	2,200	E-A	—
Canton	700	E-A	—
Chandler	2,700	E-A	—
Del City	1,700	R	—
Edmond	3,400	E-A	—
Eufaula	1,800	NP	—
Geary	1,400	E-A	—
Goodwell	1,000	E-A	—
Guymon	2,200	E-A	—
Hooker	900	E-A	—
Mooreland	500	E-A	—
Morris	900	R	—
Okemah	3,600	E-A	—
Oklahoma City	100,000	E-A	—
Okmulgee	15,200	E-A	—
Prague	1,100	E-A	—
Seiling	570	E-A	—
Seminole	11,500	E-A	—
Shattuck	1,000	E-A	—
Shawnee	21,000	NP	—
Stroud	1,900	E-A	—
Supply	1,400	E-A	—
Texhoma	400	E-A	—
Watonga	2,800	E-A	—
Weleetka	1,700	NP	—
Wetumka	2,200	E-A	—
Wewoka	10,000	E-A	—
Woodward	5,100	NP	—
Vici	600	E-A	—
Industries:			
4 oil production industry	—	4 Und.	—
319 not classified industry	—	319 Und.	—
TEXAS:			
Municipalities:			
Follett	410	E-A	—
Higgins	740	NP	—
Perryton	3,600	R	—
Spearman	1,100	NP	—
Sunray	1,200	E-A	—
Industries:			
None reported	—	—	—
KANSAS:			
Municipalities:			
Elkhart	500	E-A	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
Und. = Undetermined.
R = Replacement.
NP = New plant.

ARKANSAS RIVER BASIN
(Tulsa, Okla. to Van Buren, Ark. Sub-Basin)

Description

Geography.--This portion of the Arkansas River Basin extends from Tulsa, Okla. to Van Buren, Ark., a distance of about 170 stream miles. The drainage area contributing to the runoff in this region is 7,340 square miles excluding the Verdigris, Grand (Neosho) and Canadian Rivers, which are tributaries to the Arkansas in this area and which are discussed in other sub-basin reports. For all practical purposes, it includes that portion of the Arkansas River below Tulsa which lies within the State of Oklahoma. The stream flows in a general southwesterly direction from Tulsa to Van Buren about five miles east of the Oklahoma-Arkansas State line.

The principal tributaries to the Arkansas River in this region are the Polecat, Snake, Dirty, Sallisaw and Sansbois Creeks and the Verdigris, Grand (Neosho), Illinois, Canadian and Poteau Rivers.

Topography and Geology.--Much of the drainage area is broken and hilly although from Tulsa to below Muskogee, the area is a rolling prairie. The region from below the junction with the Canadian River is hilly consisting of ridges which merge into the Boston and Ozark mountains on the north and the Petit Jean and Maumelle mountains on the south. The stream elevation at Tulsa is 619 feet which decreases to about 375 feet at Van Buren. The Cherokee plain structures yield oil and gas.

Climate and Hydrology.--The climate in this section of the Arkansas River Basin is humid and temperate. Annual average temperature is about 61°F., with relatively long summers and short mild winters.

Precipitation over the area averages about 42 inches per year. Rainfall is well distributed throughout the year with more moisture falling during the growing season months from April through September than during the winter season.

Major tributaries entering the river in this area are heavy contributors to the flow of the Arkansas River and are major factors in producing flood flows. The recorded average, maximum and minimum flows in the Arkansas River at selected gaging stations are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
Tulsa, Okla...	74,700	9	--	173,000	147
Muskogee, Okla...	96,800	12	20,940	700,000	340
Van Buren, Ark...	150,300	20	32,330	850,000	216

Economic Development

Population.--The 1950 population of this portion of the Arkansas River Basin is approximately 484,500. The principal population centers in Oklahoma are: Tulsa - 180,586, Muskogee - 37,255, Sapulpa - 13,018, Tahlequah - 4,729, Broken Arrow - 3,251, and Sallisaw - 2,886. Ft. Smith, Ark. with a population of 47,864 is located just east of the State line.

Industry and Land Use.--The principal industrial development in this region is the production and processing of petroleum and petroleum products. Tulsa is the industrial and marketing center of the region. Agriculture is well developed with grains, corn forage crops, and livestock raising the most prevalent in this area.

Use of Water Resources

There are 25 public water supplies in the sub-basin using surface water sources. These supplies serve an estimated 307,000 persons. Ground water sources are used by 13 public water supplies serving an estimated 23,000 persons. Practically all the larger communities in this portion of Oklahoma use surface water supply sources.

Ground water supplies are adequate but in certain areas they are polluted by oil well brines. Where suitable, ground water is used appreciably by the smaller industries with independent supplies.

There are extensive land drainage projects in Tulsa County.

Pollution Data

Sewer systems and treatment facilities in the sub-basin are mostly inadequate. Pollution resulting from oil field and refinery wastes complicates the problems. Pollution may be abated through increasing minimum stream flows, installing adequate treatment for municipalities and industries, and improving treatment plant operation.

Summaries of available data on sources and amounts of pollution originating in the Arkansas River Basin (Tulsa, Okla., to Van Buren, Ark. Sub-Basin), together with existing treatment facilities and future requirements, are presented in tables A_9 through I_9.

Table A_9 shows the sources of municipal pollution in the sub-basin. There are 31 communities serving a population of 236,200 discharging wastes into the watershed streams.

Table B_9 summarizes the sources of industrial waste pollution in the sub-basin. Only three sources are classified as to type of wastes produced.

Table C_9 shows available data on existing municipal treatment facilities. There are nine communities (28 percent) serving 201,900 persons which discharge untreated wastes into the watershed streams. Twelve municipalities (38 percent) serving a population of 16,000 provide for primary treatment and 11 municipalities (34 percent) serving 18,300 persons provide for secondary treatment of their wastes before discharge into the streams.

Table D_9 summarizes data on existing industrial waste treatment facilities. No data are available as to the number of facilities and kind of treatment provided.

Table E_9 summarizes adequacy of existing waste treatment facilities. Of the 23 municipal treatment plants, 12 (52 percent) are inadequate as to capacity and 10 (43 percent) are inadequate as to operation. No data are available as to industrial facilities.

Table F_9 summarizes pollution abatement progress during the period 1946 through 1949. There were three municipal plants to serve about 18,000 persons completed during this period. No data are available for industrial waste treatment plants.

Table G_9 summarizes requirements for waste treatment facilities in the sub-basin. Municipalities will require eight new plants to serve 156,900 persons, additions to 9 plants serving 11,500 persons, and replacements for three existing plants serving 4,400 persons. No data are available for industrial wastes treatment facilities.

Table H_9 summarizes the status of treatment works projects for pollution abatement as of July 1, 1950. No action has been taken on seven municipal projects, four municipalities have plans under preparation, three municipalities have plans approved, one municipality is awaiting financing and four municipalities have plants under construction. No data are available on status of industrial wastes treatment plants.

Table I_9 shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Arkansas River Basin (Tulsa, Okla., to Van Buren, Ark. Sub-Basin) will be approximately $5,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of

Table A_9. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	31	236,200	218,000
Having population data available (Data on pollution load to watercourse incomplete or not available)	--	--	--
Total	31	236,200	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B₉. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	[1]3	Undetermined
Producing inorganic wastes	[1]3	--
Producing wastes of undetermined type	80	Undetermined
Total	[2]83	--

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Represents three sources producing both organic and inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the many industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table C₉. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*[1]	Plants	
Primary	12	12	16,000
Secondary	11	11	18,300
No treatment	9	--	201,900

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] One municipality has a primary and a secondary plant.

Table D₉. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	3	--	--	3
Miscellaneous.............	80	--	--	80
Total.................	83	--	--	83

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E₉. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	23	11	12	0	13	10	0
Industrial			(No data	available)			

Table F_9. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	No data	--
1947	1	12,800	do	--
1948	1	2,500	do	--
1949	1	2,700	do	--

Table G_9. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	8	156,900	--
Enlargement or additions to existing plant	9	11,500	--
Replace existing plant	3	4,400	--
No project required	11	18,400	--
Undetermined	1	45,000	83

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_9. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	7	--
Abatement ordered	--	--
Plans under preparation	4	--
Final plans approved	3	--
Construction awaiting financing	1	--
Under construction	4	--
Status undetermined	2	83

Table 19. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
ARKANSAS			
Municipalities:			
Ft. Smith	45,000	Und.	—
Gentry	500	E-A	—
Prairie Grove	600	E-A	—
Rogers #2	1,500	E-A	—
Industries:			
None reported	—	—	—
OKLAHOMA			
Municipalities:			
Bixby	1,000	NP	—
Boynton	700	NP	—
Broken Arrow	2,000	E-A	—
Checotah	2,100	R	—
Coweta	1,000	NP	—
Haskell	1,300	R	—
Jenks	800	NP	—
Mounds	550	E-A	—
Muskogee	30,000	NP	—
Poteau	3,200	NP	—
Quiton	1,000	E-A	—
Sapulpa	10,000	NP	—
Spiro	1,000	R	—
Stilwell	1,400	E-A	—
Tahlequah	2,500	E-A	—
Tulsa	110,200	NP	—
Wilburton	1,500	E-A	—
Industries:			
3 oil production industry	—	3 Und.	—
80 miscellaneous industry	—	80 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.
E-A = Enlargement or addition to existing plant.

ARKANSAS RIVER BASIN
(Van Buren, Ark. to Mouth Sub-Basin)

Description

Geography. --This portion of the Arkansas River watershed extends from Van Buren, Ark. to its junction with the Mississippi River upstream from Arkansas City, Ark. The stream flows diagonally across the State of Arkansas in a general southeasterly direction for a distance of about 375 miles. The watershed area of this stream stretch covers 10,200 square miles. The principal tributaries in this region are the Petit Jean, and Fourche La Fave Rivers and Bayou Meto. Minor tributaries include the Mulberry River and Piney, Point Remove and Cadron Creeks.

Topography and Geology. --The river above Little Rock flows through a rugged hilly region bordering the Boston and Ozark mountains to the north and the Petit Jean and Maumelle mountains to the south. Below Little Rock the valley blends into that of the Mississippi. Between Van Buren and Little Rock the channel width averages about 1,800 feet but occasionally narrows to 600 feet at high bluff points. Below Little Rock the channel remains wide and in the last 70 or 80 miles there is an absence of middle bars or islands.

Climate and Hydrologic Features. --The climate in this portion of the basin is humid. Mean annual temperatures are about 62°F., with a January mean of 40°F. and an August mean of 80°F. The average annual rainfall ranges from about 50 inches at Stuttgart to 43 inches at Van Buren.

The Petit Jean and Fourche La Fave Rivers are major flood contributors to the Arkansas in this region. These streams are flashy in their runoff characteristics as their headwaters are in mountainous regions. Recorded average, maximum and minimum flows for selected gaging stations in the sub-basin are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
Arkansas River--Van Buren, Ark..........................	150,300	20	32,300	850,000	216
Arkansas River--Little Rock, Ark..................	157,900	18	43,100	536,000	850
Mulberry River--Mulberry, Ark..........................	372	9	—	47,800	0.1
Petit Jean River--Danville, Ark..............	760	31	836	70,800	0
Fourche La Fave River--Nimrod, Ark................	680	11	924	36,100	0
Bayou Meto--Stuttgart, Ark.............	—	12	507	6,550	0

Economic Development

Population. --The 1950 population of the sub-basin area is about 469,000. The principal population centers are Little Rock - 101,387, North Little Rock - 42,142, Pine Bluff - 37,147, Conway - 8,546, Russellville - 8,135, Stuttgart - 7,094, Van Buren - 6,399, Morrilton - 5,462, and Clarksville - 4,350.

Industry and Land Use. --Agriculture is the leading occupation in the region and is extensively developed throughout the sub-basin. Below Little Rock, cotton is the principal crop. In the more mountainous regions grazing is important and hardwood lumbering is carried on locally. Coal mined in the area is important to the steel industry in the West. The Little Rock area is the principal industrial and marketing center.

Use of Water Resources

There are 20 communities in the sub-basin which use surface sources for their public water supplies and serve about 237,600 persons. Sixteen public water supplies are derived from ground water sources and serve 58,000 persons.

In Arkansas good underground water can be obtained in adequate quantities from either shallow or deep wells throughout the overflow plains of the main stream, elsewhere it is more limited, but is generally adequate except in the Fourche La Fave Basin and in some other highland areas.

Soil erosion and silting are serious problems. Extensive soil erosion occurs in the highlands regions. Water conservation in this area has not been considered seriously in the past.

Pollution Data

Pollution in the lower reach of the Arkansas River has not been a serious problem, due primarily to the limited use of these waters and to the large flows available for dilution.

Summaries of available data on the sources and amounts of pollution originating in this portion of the Arkansas Basin together with data on existing treatment facilities and future requirements, are presented in tables A_{10} through I_{10}.

Table A_{10} shows 23 municipal pollution sources, serving a population of 189,800, discharging wastes to the watershed.

Table B_{10} summarizes the sources of industrial waste pollution on the watershed. No data regarding industrial sources are available.

Table C_{10} summarizes existing municipal treatment facilities in this portion of the Arkansas River Basin. Of the 23 municipalities in this sub-basin, seven or 30 percent serving 151,300 persons discharge untreated wastes into the watercourses; 11 or 48 percent serving 24,000 persons provide for primary treatment of their wastes before discharge; and five or 22 percent serving 14,500 persons provide for secondary treatment before discharging of their wastes into the sub-basin streams.

Table D_{10} shows that there are no data regarding industrial waste treatment facilities in this sub-basin.

Table E_{10} summarizes the adequacy of existing treatment facilities in the sub-basin. Of the 17 municipal plants, 14 or 82 percent are inadequate as to capacity and 15 or 88 percent are inadequate as to operation.

Table F_{10} summarizes the progress in pollution abatement for the period 1946 through 1950. Two municipal treatment plants serving 4,400 persons were placed in operation in this sub-basin during that period.

Table G_{10} summarizes the requirements for municipal waste treatment plants in this sub-basin. Ten plant additions to serve 25,000 persons and four plant replacements to serve 8,000 persons will be required.

Table A_{10}. Sources of pollution, municipal

Municipal-ities*	Sources of pollution (in number of munici-palities)	Population served by sewerage system	Amount of pollution discharged to water-course (in terms of equivalent number of people)**
Having data on pollution load dis-charged to watercourse	23	189,800	172,000
Having popu-lation data available (Data on pollution load to watercourse incomplete or not available)	—	—	—
Total	23	189,800	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table H_{10} shows data available on the status of treatment works projects to abate pollution as of July 1, 1950.

Table I_{10} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Arkansas River Basin (Van Buren, Ark., to Mouth Sub-Basin) will be approximately $2,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers. No plant is included in the estimate for Little Rock, the largest city in the sub-basin.

The lack of data regarding other sources of industrial pollution precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table B_{10}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	No data	—
Producing organic wastes	do	—
Producing inorganic wastes	do	—
Producing wastes of undetermined type	do	—
Total	do	—

*Industries having separate outlets and discharging wastes directly to watercourse.

Table C_{10}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities* 1	Plants	
Primary	11	12	24,000
Secondary	5	5	14,500
No treatment	7	--	151,300

*Includes incorporated or uncorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] One municipality has two primary plants, and one municipality with two outfalls has no treatment facilities.

Table D_{10}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
	(No data available)			

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{10}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	17	3	14	0	2	15	0
Industrial			(No data available)				

Table F_{10}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	No data	--
1947	1	24,400	do	--
1948	0	--	do	--
1949	0	--	do	--
1950	1	2,000	do	--

Table G_{10}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	--	--	--
Enlargement or additions to existing plant	10	25,000	--
Replace existing plant	4	8,000	--
No project required	3	5,500	--
Undetermined	8	151,300	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_{10}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	--	--
Abatement ordered	--	--
Plans under preparation	--	--
Final plans approved	1	--
Construction awaiting financing	--	--
Under construction	--	--
Status undetermined	21	--

Table I_{10}. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
ARKANSAS			
Municipalities:			
Alma........................	500	E-A	—
Atkins........................	1,000	E-A	—
Booneville....................	1,100	E-A	—
Carlisle......................	1,000	E-A	—
Clarksville...................	3,500	Und.	—
Charleston....................	600	E-A	—
Conway........................	8,500	E-A	—
Dardanelle....................	2,000	Und.	—
England.......................	2,000	R	—
Little Rock...................	95,000	Und.	—
Lonoke........................	2,000	R	—
Morrilton #1..................	2,000	R	Will replace two plants with one
#2..................	2,000	R	
Mulberry......................	450	E-A	—
North Little Rock.............	22,000	Und.	—
Ozark.........................	1,300	Und.	—
Paris.........................	3,300	E-A	—
Pine Bluff SD# 1 and 2........	20,000	Und.	—
SD# 21............	3,000	Und.	—
Russellville..................	4,000	E-A	—
Stuttgart.....................	4,500	E-A	—
Van Buren.....................	4,500	Und.	—
Industries:			
None reported.................	—	—	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.
E-A = Enlargement or addition to existing plant.

LOWER MISSISSIPPI RIVER BASIN
(Yazoo River Sub-Basin)

Description

Geography.--This sub-basin consists of the drainage area of the Yazoo River in western Mississippi. The Yazoo River rises in north central Mississippi and flows generally southward to its junction with the Mississippi River at Vicksburg. The stream has a total length of about 300 miles and has a watershed area of 11,700 square miles lying entirely within the State of Mississippi. The principal tributaries are the Coldwater, Tallahatchie, Yokena, Yalobusha, and Sunflower Rivers.

Topography and Geology.--Topographically, the sub-basin is divided into two distinct areas: the Yazoo Delta to the west, a long narrow oval of low alluvial lands with a maximum width of 65 miles and an area of 6,600 square miles; and an irregular belt of severely eroded uplands to the east. Tributaries from the east traverse the uplands regions. The delta is formed from alluvial deposits of the Mississippi River and from sediments carried down by the Yazoo eastern tributaries. It includes some of the most productive lands in the State of Mississippi. The streams wind in tortuous channels through the delta area.

Climate and Hydrology.--The climate is mild and humid while the mean annual temperature is about 65°F. Rainfall averages about 50 to 55 inches per year, more than half of which falls during the period from April through September.

Stream flow variations are wide and floods resulting from rapid runoff from the badly eroded uplands are common in the upper delta regions. Recorded average, maximum and minimum stream flows from selected gaging stations are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
MISSISSIPPI					
Tallahatchie River--Etta.................	526	9	758	32,600	4
Tallahatchie River--Sardis Dam...........	1,545	7	---	5,860	0
Tallahatchie River--Swan Lake............	5,130	9	6,859.	43,200	213
Yazoo River--Greenwood...................	7,450	13	9,602	72,900	536
Yokena River--Enid.......................	560	12	753	25,400	20
Coldwater River--Arkabutla Dam...........	1,000	5	---	10,200	0
Yalobusha River--Grenada.................	1,550	14	1,864	76,800	35
Sunflower River--Sunflower...............	780	9	1,014	7,700	27

Economic Development

Population.--The 1950 population of the sub-basin is approximately 704,000 and is predominately rural. Principal population centers are Vicksburg - 27,344, Clarksdale - 16,515, Greenwood - 18,002, Greenville - 29,914, Yazoo City - 7,983, and Grenada - 7,387.

Industry and Land Use.--Agriculture is the major activity in the sub-basin. Cotton is the most important crop followed by corn. Other crops are soybeans, small grains, and alfalfa. Cattle raising is also an important economic activity. The upland areas are badly eroded and land formerly cultivated has been abandoned for this reason.

Manufacturing in the sub-basin is on a limited scale. However, there are 410 small industries operating in the sub-basin which include textiles, chemicals, food products, lumber products, printing and ceramics.

There are two oil fields in the sub-basin.

Use of Water Resources

Vicksburg is the only community in the sub-basin using surface water as a source of public water supply and serves a population of 24,500. Eighty-four communities utilize ground water sources to serve 142,000 persons. Ground water sources are of good quality and are of abundant supply. Artesian water is available but waste by means of uncontrolled water flow is depleting the ground water supply.

Lakes in the region are extensively used for recreational purposes, as are two flood control reservoirs at Sardis and Arkabutla located on the Tallahatchie and Coldwater rivers.

Pollution Data

Pollution at present is not of sufficient concentration to degrade the streams. Local nuisance conditions are found on some of the smaller branches or drains. Oil field wastes above Vicksburg may eventually affect the Vicksburg water supply.

Summaries of the available data on the sources and amounts of pollution originating in the Yazoo River Sub-Basin, together with existing treatment facilities and requirements, are presented in tables A_{11} through I_{11}.

Table A_{11} summarizes the pollution sources of municipal origin in the sub-basin. There are 42 such sources with a combined sewered population of 127,100 persons.

Table A_{11}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	42	127,100	110,100
Having population data available (Data on pollution load to watercourse incomplete or not available)	—	—	—
Total	42	127,100	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{11} summarizes the pollution sources from industry in the sub-basin. There are 53 such sources.

Table C_{11} is a summary of existing municipal treatment facilities in the Yazoo Sub-Basin. Of the 42 communities with sewer systems, 18 (43 percent) serving 88,800 persons provide no treatment; 20 or 47 percent serving 26,200 persons provide for primary treatment; and four (10 percent) serving 12,100 persons provide for secondary treatment before discharging their wastes to the sub-basin streams.

Table D_{11} summarizes existing industrial waste treatment facilities. The kind of treatment facilities provided by 51 plants listed are not known.

Table E_{11} summarizes the adequacy of existing waste treatment facilities. Of the 24 municipalities having treatment facilities, eight (33 percent) are unsatisfactory as to capacity and eight (33 percent) are inadequate as to operation. Adequacy of any treatment facilities provided by industry is not known.

Table F_{11} summarizes progress in pollution abatement in the Yazoo Sub-Basin during the period 1946 through 1949. No progress is recorded.

Table G_{11} summarizes requirements for municipal and industrial waste treatment. Eight municipalities serving 25,500 persons require new treatment plants; two communities serving 2,300 persons require plant enlargements; and eight municipalities serving 16,600 persons require plant replacements. Data are not available for industry.

Table H_{11} shows no data available on the status of treatment works projects as of July 1, 1950.

Table I_{11} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Lower Mississippi River Basin (Yazoo River Sub-Basin) will be approximately $1,500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the different kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table B_{11}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	49	Undetermined
Producing inorganic wastes	3	—
Producing wastes of undetermined type	1	Undetermined
Total	53	—

*Industries having separate outlets and discharging wastes directly to watercourse.

Table C_{11}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	20	20	26,200
Secondary	4	4	12,100
No treatment	18	—	88,800

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D_{11}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products...	30	—	—	30
Chemical and allied products...	2	0	2	0
Miscellaneous...	21	—	—	21
Total...	53	—	2	51

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{11}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	24	16	8	0	16	8	0
Industrial			(No data available)				

Table F_{11}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	0	—	do	—
1949	0	—	do	—

Table G_{11}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	8	25,500	—
Enlargement or additions to existing plant	2	2,300	—
Replace existing plant	[1]8	16,600	—
No project required	24	82,700	—
Undetermined	0	—	53

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes 2 plants reported as having adequate capacity, but which require replacement to provide a higher degree of treatment.

Table H_{11}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	—	—
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	18	53

Table I_{11}. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
MISSISSIPPI			
Municipalities:			
Batesville	1,400	NP	—
Calhoun City	800	E-A	—
Clarksdale	10,000	NP	—
Grenada	4,000	NP	—
Hernando	1,500	E-A	—
Hollandale	1,500	R	—
Holly Springs	3,000	R	—
Lexington	2,500	R	—
Marks	1,600	NP	—
Moorhead	1,500	NP	—
New Albany	3,000	NP	—
Olive Branch	500	R	—
Oxford	5,000	R	—
Sardis	1,600	R	—
Senatobia	1,500	NP	—
Shelby	1,500	R	—
Tunica	1,000	R	—
Water Valley	2,500	NP	—
Industries:			
30 food and kindred products	—	30 Und.	—
2 chemical and allied products	—	2 Und.	—
21 miscellaneous industries	—	21 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.
E-A = Enlargement or addition to existing plant.

SOUTH CANADIAN RIVER SUB-BASIN
(Above Texas-Oklahoma State Line)

Description

Geography.--This sub-basin includes only that portion of the South Canadian River in the States of New Mexico and Texas. The stream rises in the high eastern slopes of the Cimarron and Sangre de Cristo Mountains in northeastern New Mexico and flows in a southerly direction to San Miguel County, New Mexico, then easterly through New Mexico and Texas. The stream length to the Oklahoma State line is approximately 600 miles and the drainage basin embraces about 22,600 square miles of which 14,300 are in New Mexico and 8,300 are in Texas. About 50 percent of the entire South Canadian River Sub-Basin area is in New Mexico and 30 percent is in Texas. The remaining portion is in Oklahoma. There are numerous short tributaries in the headwaters area in New Mexico which arise along the mountain slopes. These streams are perennial and serve as sources of irrigation water in the region. Principal tributaries in this sub-basin are: Vermejo River, Cimarron River, Ocate Creek, Mora River, Conchas River, Pajarito Creek, Trementina Creek, Ute Creek, and Tucumcari Creek all in New Mexico; and, Major Longs Creek and Red Deer Creek in Texas.

Topography and Geology.--The topography in the headwaters area in New Mexico is rough and broken and is cut by numerous tributaries which arise in the mountains at elevations of 12,000 feet. Below Taylor Springs, N. Mex., the stream enters a narrow canyon which extends to Sanchez, N. Mex. Below Sanchez the stream enters another canyon which disappears above the mouth of the Conchas River. Below the Conchas, the river enters a wide gravelly valley. The river cuts itself deeper into the plains formation as it crosses the remaining part of New Mexico and at the Texas line, it lies in a canyon 300 to 400 feet deep. The river flows through Texas in a broad deep canyon 400 to 600 feet below the plains surface. The valley floor is flat and sandy from one-half to three-fourths of a mile in width and is bordered by abrupt bluffs. Lateral drainage 10 miles or so back from either side of the river, is deeply eroded. The area is very rough and suitable for grazing lands only. The plains area on either side of the river beyond this rough area is solidly formed and is very fertile. The plains give way to rolling prairie near the Oklahoma line but the valley narrows as the Texas-Oklahoma State line is reached. The geologic formations are sedimentary shales and sandstone of varying hardness, color and thickness through much of the New Mexico-Texas region. Easily eroded formations make the stream a heavy sand and silt carrier in times of heavy runoff.

Stream elevations vary from 8,000 feet at the source to about 1,500 feet at the Oklahoma State line.

Climate and Hydrologic Features.--The climate is semiarid to arid. Mean annual temperatures vary with elevation, being lower in the mountain regions and higher in the plains area. Wider extreme temperatures are found on the plains.

Rainfall varies from 26 inches per year in the higher mountains to about 15 inches near Taylor Springs, N. Mex. and then increases eastward. The average over the sub-basin is about 19 inches per year. About 75 percent of the annual rainfall occurs from April through September.

Stream flows in the sub-basin are erratic. Tributaries in the mountains are perennial streams which supply irrigation demands during the summer season. All other tributaries are intermittent in flow.

Average, maximum and minimum recorded stream flows at gaging stations in this portion of the South Canadian River Sub-Basin are tabblated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
South Canadian River--Taylor Springs, N. Mex.	2,740	7	—	37,400	0
South Canadian River--West of Roy, N. Mex.	4,000	11	197	63,800	0
South Canadian River--Sanches, N. Mex.	6,000	13	394	87,800	0
South Canadian River--Logan, N. Mex.	11,200	14	408	219,000	0
South Canadian River--Amarillo, Tex.	19,200	10	679	135,000	0
South Canadian River--Canadian, Tex.	22,620	9	—	122,000	0
Vermejo River--Dawson, N. Mex.	250	23	22	—	0

Economic Development

Population. --The 1950 population in the sub-basin area is approximately 186,000. The principal population centers are: Raton - 7,927, Tucumcari - 8,369, Springer - 1,566, Mora - 1,440, Wagon Mound - 1,132, and Roy - 1,127 in New Mexico; and Amarillo - 73,737, Borger - 17,949, Dalhart - 5,899, Canadian - 2,671, and Dumas - 6,108 in Texas.

Industry and Land Use. --Agriculture, including livestock raising is the major industry in the sub-basin. In New Mexico farming is dependent upon irrigation. In the Texas Panhandle the principal crop is wheat raised on dry farmed plains lands. Cattle and sheep are extensively raised in both New Mexico and Texas.

Extensive coal fields have been operated near Dawson, N. Mex. The fields are not being worked, due to lack of market, although the reserves of coal are large. Some coal fields are still operated near Koehler. Petroleum and natural gas are produced in the Panhandle of Texas, particularly in the central portion. The petrochemical industry in the Panhandle area is growing rapidly. Water supply and pollution problems are of major concern to these industries. Zinc smelting near Dumas, and at Amarillo, Tex., is an important industry.

Recreational activities are of potential value in the mountainous headwaters areas where fishing and hunting are possible.

Use of Water Resources

Five communities serving 12,500 persons use surface waters as sources of their public water supplies. Ground water sources are utilized by 21 communities serving 122,000 persons.

Drought conditions greatly affect rural ground water supplies in this portion of the South Canadian River Sub-Basin.

Industries located in the New Mexico portion of the sub-basin utilize both surface and ground waters as sources of supplies. The industrial water needs of the chemical plants and refineries in the Texas portion are obtained mainly from well supplies.

The conservation of water is important in this sub-basin and multiple water use is necessary to provide for the needs of the area.

The Conchas Dam and Reservoir located in New Mexico serves as a flood control project and provides conservation storage for other water uses. About one-fourth of the drainage area of the South Canadian River is above this dam and reservoir.

Pollution Data

Stream pollution in this sub-basin is primarily of local importance. Where waters containing sewage discharges may be used for irrigation of truck crops special considerations concerning the health hazard are involved. Oil field wastes add to the pollution problems in those areas where petroleum or gas production occurs. Natural pollution, caused by mineralization of the river waters as they course through the highly mineralized regions, is one of the major factors which limits the use of the streams for municipal and industrial supplies.

Summaries of the available data on sources and amounts of pollution originating in this portion of the South Canadian River Sub-Basin, together with existing treatment facilities and requirements, are presented in tables A_{12} through I_{12}.

Table A_{12} summarizes the sources of municipal pollution in the sub-basin. There are 16 communities with a sewered population of 101,800 producing domestic wastes.

Table A_{12}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	15	93,800	25,000
Having population data available (Data on pollution load to watercourse incomplete or not available)	1	8,000	--
Total	16	101,800	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{12}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	1	Undetermined
Producing inorganic wastes	5	--
Producing wastes of undetermined type	1	Undetermined
Total	7	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Table B_{12} is a summary of the known industrial waste pollution sources in the sub-basin. There are seven such sources of pollution.

Table C_{12} summarizes the existing municipal treatment facilities. Of the 16 sewered communities in this sub-basin, one (6 percent) serving a population of 7,000 has no treatment facilities; nine (56 percent) serving 16,500 persons provide for primary treatment; and six (38 percent) serving 78,300 provide for secondary treatment of their wastes.

Table D_{12} summarizes existing industrial waste treatment facilities. Five plants (71 percent) have no treatment facilities and in two cases facilities were not determined.

Table E_{12} summarizes the adequacy of existing treatment facilities. Of the 15 municipalities having treatment works, seven (47 percent) are unsatisfactory as to capacity and five (33 percent) are inadequate as to operation. No data are available regarding industrial facilities.

Table F_{12} summarizes pollution abatement progress in this sub-basin during the period from 1946 through 1949. There were four municipal installations serving 18,500 persons placed in operation during this period. No data are available for industrial plants.

Table G_{12} summarizes requirements for municipal and industrial waste treatment plants. A new plant is required for one community serving 7,000 persons and replacement of three plants serving 66,600 is required. No enlargements of existing plants are necessary. No projects are required in the case of six industrial plants.

Table H_{12} summarizes the status of treatment works projects as of July 1, 1950, to abate pollution. Plans have been approved for two municipal projects.

Table I_{12} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the South Canadian River Sub-Basin (Above Texas-Oklahoma State Line) will be approximately $500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the various kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table C_{12}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	9	9	16,500
Secondary	6	6	78,300
No treatment	1	--	7,000

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D_{12}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Other mining industries...	5	0	5	0
Food and kindred products.	1	--	--	1
Miscellaneous.............	1	--	--	1
Total..................	7	--	5	2

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{12}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	15	7	7	1	8	5	2
Industrial			(No data available)				

Table F_{12}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	2	3,500	do	—
1949	2	15,000	do	—

Table G_{12}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	1	7,000	—
Enlargement or additions to existing plant	0	—	—
Replace existing plant	3	66,600	—
No project required	[1]12	28,200	6
Undetermined	0	0	1

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes 4 plants with units of unsatisfactory capacity and 1 plant of undetermined capacity, which at the present time have no project requirements.

Table H_{12}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	1	—
Abatement ordered	—	—
Plans under preparation	—	—
Final plans approved	2	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	1	1

Table I_{12}. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
NEW MEXICO			
Municipalities:			
Roy	1,000	R	Plans completed
Tucumcari	7,000	NP	Plans completed
Industries:			
1 food and kindred products	—	1 Und.	—
TEXAS			
Municipalities:			
Amarillo	65,000	R	—
Stinnett	635	R	—
Industries:			
None reported	—	—	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**R = Replacement of existing plant.

Und. = Undetermined.

NP = New plant.

SOUTH CANADIAN RIVER SUB-BASIN
(Below Texas-Oklahoma State Line)

Description

Geography. --This sub-basin consists of that portion of the South Canadian River which lies within the State of Oklahoma. The watershed of the South Canadian River in Oklahoma covers an area of about 7,100 square miles. It extends across central Oklahoma in a generally southeasterly direction to the junction of the Canadian River with the Arkansas River south of Muskogee, Okla. The sub-basin is long and narrow with a length of 200 miles and a width ranging from 10 to 25 miles. There are no important tributaries until the Little River is reached, a short distance above Calvin, Okla. The South Canadian River joins with the North Canadian in the vicinity of Eufaula, Okla., about 40 miles above the mouth of the Canadian River.

Topography and Geology. --The river occupies a wide meandering channel with low banks across the State to the vicinity of Norman, Okla., where the bank heights increase gradually to 20 or 30 feet above the stream bed. The lands adjacent to the lower section of the river are heavily timbered.

West of Taloga, Okla., the principal geologic formations are sedimentary shales and sandstone. Eastward the formations consist of older sandstones, shales, and limestones. The easily eroded materials of the western portions of the sub-basin cause heavy silt and sand carriage by the stream during high runoff.

Climate and Hydrologic Features. --The climate in the sub-basin is temperate and humid. Mean annual temperature is about 61°F. The average annual rainfall in the Oklahoma portion of the sub-basin is about 33 inches. Distribution is fairly uniform throughout the year. Minimum precipitation occurs during the months of November, December, January, and February. Maximum annual rainfall of record in this sub-basin was 50.54 inches in 1908 and the minimum was 19.24 inches in 1910.

Average, maximum, and minimum stream flows of record for gaging stations on the South Canadian River in Oklahoma are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Steam flow (c.f.s.)		
			Average*	Maximum	Minimum
OKLAHOMA					
Bridgeport.....	26,050	3	543	57,000	0
Calvin.....	28,700	11	2,299	150,000	0
Whitefield.....	47,370	9	8,284	281,000	65

*For water year 1947.

Economic Development

Population. --The 1950 population in the sub-basin is approximately 215,000. The principal population centers are Norman - 26,972, Ada - 15,935, Holdenville - 6,191, Purcell - 3,527, Eufaula - 2,538, and Konawa - 2,699.

Industry and Land Use. --The greater part of the land in this sub-basin has some oil lease value and a small part of it is oil producing. Agriculture is the major land use. Corn and cotton are the principal crops.

Cement manufacture and other non-metallic mineral industries including production of dolomite, rock and gravel, rock asphalt, and glass sand in the vicinity of Ada, Okla., produce a considerable share of the industrial income of the area.

Use of Water Resources

Surface water sources are used by four communities for public water supplies serving about 36,000 persons. Twenty-eight communities serving about 50,000 persons obtain their public water supplies from underground sources. Drought conditions seriously affect the underground water resources and rural water supplies are jeopardized as a result.

Pollution Data

Summaries of available data on sources and amounts of pollution originating in the Oklahoma portion of the South Canadian River Sub-Basin, together with the existing treatment facilities and future requirements, are presented in tables A_{13} through I_{13}.

Table A_{13} shows 23 communities, serving 66,700 persons, as discharging wastes into the streams of this sub-basin.

Table B_{13} shows the sources of pollution originating from industry. Data regarding industrial wastes in general are not complete.

Table C_{13} summarizes existing municipal treatment facilities in the sub-basin. Of the 23 communities having sewer systems, one serving 2,900 persons provides for no treatment; six (26 percent) serving 6,000 persons provide for primary treatment; and 16 (70 percent) serving 57,800 persons provide for secondary treatment before discharging their wastes into the streams.

Table D_{13} summarizes existing industrial wastes treatment facilities in the sub-basin. No data are available regarding these facilities.

Table E_{13} summarizes adequacy of existing treatment facilities in the sub-basin. Of the 23 municipal treatment facilities, 12 (52 percent) are inadequate as to capacity and four (17 percent) are inadequate as to operation. No data are available as to the adequacy of industrial waste treatment plants.

Table F_{13} summarizes the progress made in pollution abatement for the period 1946 through 1949. There were two municipal treatment plants placed in operation to serve 21,000 persons during this period. No data are available for industrial plants.

Table G_{13} summarizes requirements for waste treatment facilities for the sub-basin. Requirements for municipal treatment plants include: one new plant to serve 2,900 persons; 15 enlargements of existing plants serving 40,300 persons and replacement of one plant serving 2,000 persons. There are no data available for industrial plants.

Table H_{13} summarizes the status of treatment works projects for pollution abatement as of July 1, 1950. One community has plans under preparation. There are no data for the status of industrial plants.

Table I_{13} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the South Canadian River Sub-Basin (Below Texas-Oklahoma State Line) will be approximately $1,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_{13}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	23	66,700	30,400
Having population data available (Data on pollution load to watercourse incomplete or not available)	—	—	—
Total	23	66,700	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{13}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	[1] 5	Undetermined
Producing inorganic wastes	[1] 5	--
Producing wastes of undetermined type	117	Undetermined
Total	[2] 122	--

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Represents five sources producing both organic and inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

Table C_{13}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities *1	Plants	
Primary	6	6	6,000
Secondary	16	17	57,800
No treatment	1	--	2,900

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] One municipality has two secondary plants.

Table D_{13}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry...	5	--	--	5
Miscellaneous.............	117	--	--	117
Total.................	122	--	--	122

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{13}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	23	11	12	0	19	4	0
Industrial			(No data available)				

Table F_{13}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	No data	--
1947	0	--	do	--
1948	0	--	do	--
1949	2	21,000	do	--

Table G_{13}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	1	2,900	--
Enlargement or additions to existing plant	[1]15	40,300	--
Replace existing plant	1	2,000	--
No project required	7	21,500	--
Undetermined	0	--	122

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes 4 plants where existing units have adequate capacity, but which require additional units to provide a higher degree of treatment.

Table H_{13}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	14	--
Abatement ordered	--	--
Plans under preparation	1	--
Final plans approved	--	--
Construction awaiting financing	--	--
Under construction	--	--
Status undetermined	2	122

Table I_{13}. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
OKLAHOMA			
Municipalities:			
Ada	11,300	E-A	—
Custer City	500	E-A	—
Hartshorne	2,000	R	—
Hinton	600	E-A	—
Holdenville	6,400	E-A	—
Hydro	500	E-A	—
Konawa	2,100	E-A	—
Minco	800	E-A	—
Moore	400	E-A	—
Noble	450	E-A	—
Norman	9,500	E-A	—
Purcell	2,900	NP	—
Stigler	1,200	E-A	—
Stratford	700	E-A	—
Thomas	1,100	E-A	—
Tuttle	800	E-A	—
Weatherford	4,000	E-A	—
Industries:			
5 oil production industry	—	5 Und.	—
117 miscellaneous industry	—	117 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.

R = Replacement of existing plant.

Und. = Undetermined.

NP = New plant.

WASHITA RIVER SUB-BASIN

Description

Geography.--The Washita River arises in Hemphill County, Texas, and flows in a generally easterly direction through the Texas Panhandle and western Oklahoma to near Paul's Valley, Okla., where it turns southeast and enters the Red River near Denison, Tex. The Washita is the principal tributary of the Red River in Oklahoma. The stream has a total length of about 500 miles and embraces a drainage area of 8,100 square miles, of which 7,640 are in Oklahoma and 460 are in Texas. The drainage sub-basin is long and narrow and it is bounded on the north by the Canadian, on the east by the Lower Red and on the southwest by the Upper Red River Sub-Basin.

Topography and Geology.--The drainage sub-basin is composed of two characteristic areas. The western half is in the semiarid plains country of Texas and Oklahoma and the eastern half is in the rolling plains of central Oklahoma. Elevations in the sub-basin vary from about 3,000 feet at the headwaters to about 500 feet near the mouth. The average stream slope is about two and one-half feet per mile in the lower 250 miles of the river. The stream flows in a fairly stable and well-defined channel with steep banks. The overflow plain is generally cultivated. Vegetation on the mountain ridges in the eastern third of the sub-basin is post and blackjack oak and grass prevails in the western third. Serious erosion occurs on the uplands in the sub-basin.

Climate and Hydrologic Features.--The annual average temperature in the sub-basin is 61.5°F., with an average of 59.5°F. in the upper and 63.4°F. in the lower portion of the sub-basin. Temperatures range from a maximum of 116°F. to a minimum of -17°F. Precipitation ranges from 22 inches per year in the upper part of the sub-basin to 38 inches per year in the lower part. Coincidence of low rainfall and very hot weather in July and August often give rise to severe drought conditions. It is entirely possible for crops to be injured by both flood and drought in the same year, since storms of cloudburst intensity are not infrequent and often give rise to damaging floods when they occur. Recorded average, maximum, and minimum stream flows at various gaging stations are presented in tabular form in the next column:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.) Average	Maximum	Minimum
OKLAHOMA					
Clinton....	1,990	12	170	26,900	1
Carnegie...	3,230	10	343	12,000	7
Tabler.....	4,760	7	--	38,000	26
Pauls Valley...	5,390	9	--	22,000	24
Durwood...	7,310	10	1,712	91,300	17

Economic Development

Population.--The 1950 population in the sub-basin area is approximately 186,000. The principal population centers all in Oklahoma are: Chickasha - 15,753, Clinton - 7,545, Pauls Valley - 6,867, Anadarko - 6,164, Sulphur - 4,373, and Cordell - 2,878.

Industry and Land Use.--Farming and ranching areas about equally divide the Washita Sub-Basin. Wheat, corn, and forage crops are dominant in the western portion and cotton dominates the central and eastern portions. There are about 200 cotton gins, compresses, and oil mills operating in the sub-basin, in addition to several other types of industrial plants which process products of the area.

The sub-basin contains some major gas fields, as well as highly productive oil wells of the "Anadarko Basin." Oil refineries are located along the south-central border of the sub-basin.

Gypsum, limestone, asphalt, granite, and clay are available commercially in the area.

Use of Water Resources

Nearly all of the communities in the sub-basin have public water supplies, the majority of which are obtained from ground water sources. Five communities utilize surface supplies to serve about 32,000 persons. Two of these communities, Anadarko (6,164) and Chickasha (15,753), draw their supplies from the main stem of the Washita River. Twenty-nine communities use ground water sources of supply to serve about 36,000 persons.

The development of plans for better utilization of waters in the sub-basin has been undertaken by the Oklahoma Water Resources Committee.

Better facilities for recreation and wildlife conservation are needed in the sub-basin.

Pollution Data

The Washita River and many of its tributaries are grossly polluted. Some pollution is caused by oil well drainage. Pollution affects water supplies in the sub-basin which are derived from surface water sources.

Summaries of available information on amounts and sources of pollution originating in the Washita Sub-Basin, together with existing treatment facilities and requirements, are presented in tables A_{14} through I_{14}.

Table A_{14}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	[1]30	62,400	29,200
Having population data available (Data on pollution load to watercourse incomplete or not available)	—	—	—
Total	30	62,400	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

[1] Includes two municipalities that have planned construction of sewer systems.

Table A_{14} summarizes the pollution reaching the sub-basin streams from municipal sources. There are a total of 30 sewered communities serving an estimated population of 62,400 persons.

Table B_{14} summarizes the industrial waste pollution sources in the sub-basin.

Table C_{14} shows the number of existing municipal treatment facilities. Of the 30 cities, five (17 percent) serving 13,100 persons do not provide any treatment for their wastes; 16 (53 percent) serving 15,900 persons, provide for primary treatment; and nine (30 percent) serving 33,400 provide for secondary treatment before discharging their wastes into the sub-basin watercourses.

Table D_{14} summarizes existing industrial waste treatment facilities.

Table E_{14} summarizes adequacy of existing waste treatment facilities. Of the 25 municipal installations, 22 (88 percent) are inadequate as to design and 15 (60 percent) are inadequate as to operation.

Table F_{14} shows the progress made in pollution abatement in the sub-basin during the period 1946 through 1950.

Table G_{14} summarizes the requirements for waste treatment plants in the sub-basin. New plants are required in the cases of five communities serving 13,100 population; enlargements or additions are required for 14 municipal installations serving 24,700 persons and eight installations serving 7,000 persons require replacement.

Table H_{14} summarizes the status of treatment works projects for pollution abatement as of July 1, 1950. Six municipalities had plans in the process of preparation.

Table I_{14} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Washita River Sub-Basin will be approximately $1,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table B_{14}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	[1]2	Undetermined
Producing inorganic wastes	15	--
Producing wastes of undetermined type	0	--
Total	[2]15	--

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Represents two sources also listed as producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

Table C_{14}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	16	16	15,900
Secondary	9	9	33,400
No treatment	5	--	13,100

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D_{14}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	13	9	4	0
Products of petroleum and coal....................	2	0	2	0
Total................	15	9	6	0

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{14}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	25	2	22	1	5	15	5
Industrial	9	3	6	0	9	0	0

Table F_{14}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	No data	--
1947	0	--	do	--
1948	1	20,000	do	--
1949	2	4,000	do	--
1950	0	--	do	--

Table G_{14}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	5	13,100	5
Enlargement or additions to existing plant	14	24,700	6
Replace existing plant	8	7,000	--
No project required	2	16,800	3
Undetermined	1	800	1

*The needs set forth in this table are based on presently available information.

However, future studies and evaluations may result in some changes in these needs.

Table H_{14}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	18	--
Abatement ordered	0	--
Plans under preparation	6	3
Final plans approved	2	--
Construction awaiting financing	0	--
Under construction	2	--
Status undetermined	0	9

Table I_{14}. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
OKLAHOMA			
Municipalities:			
Alex	420	R	—
Anadarko	6,400	NP	—
Binger	400	R	—
Carnegie	1,700	R	—
Cement	840	E-A	—
Cheyenne	1,100	NP	—
Clinton	7,200	E-A	—
Cyril	850	E-A	—
Davis	1,500	R	—
Ft. Cobb	650	E-A	—
Gotebo	450	E-A	—
Hammon	320	E-A	—
Kingston	480	NP	—
Leedy	600	NP	—
Lindsay	3,000	E-A	—
Madill	2,000	E-A	—
Marlow	1,800	E-A	—
Maysville	1,200	E-A	—
Mt. View	1,000	E-A	—
Pauls Valley	4,500	NP	—
P. V. State Hospital	850	R	—
R. S. Indian School	400	R	—
Rush Springs	1,000	R	—
Sulphur	3,900	E-A	—
Tishomingo	1,400	E-A	—
Verden	500	E-A	—
Western T. B. Hospital	430	E-A	—
Wynnewood	800	R	—
Industries:			
10 oil production industries	—	4 NP, 6 E-A	—
2 products of petroleum	—	1 Und, 1 NP	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.

UPPER RED RIVER SUB-BASIN
(Above Denison, Tex.)

Description

Geography.--The Red River rises in the high plains section of the Texas Panhandle at an altitude of about 4,000 feet. The river flows eastward across the Texas Panhandle to the 100th meridian from which point eastward it becomes the boundary between Texas and Oklahoma. The stream continues eastward past the 100th meridian to its junction with the Washita River near Denison, Tex. which point marks the eastern end of the Upper Red River Sub-Basin. From its source to Denison, the stream is about 540 miles in length and the drainage area embraces about 30,500 square miles of which 21,700 are in Texas, 8,750 are in Oklahoma and 50 are in New Mexico. The upper 300 mile reach of the river is known as "Prairie Dog Town Fork". The principal tributaries are the Wichita, Little Wichita, Pease, Salt Fork, North Fork, Cache and Beaver Rivers.

Topography and Geology.--The headwaters area is semiarid in character and the river develops from a network of small streams. Slopes are steep and flows are intermittent except in flood. The main river bottom through western Oklahoma is poorly defined and shifts in the sandy waste. East of the "bad lands" lie the rolling plains section of Texas and Oklahoma. The rugged Wichita Mountains form the northern divide.

Climate and Hydrology.--The climate of this portion of the Upper Red River Sub-Basin may be considered as moderate except for the semiarid section at the headwaters of the river. The average annual temperature approaches 65°F., winters are generally mild and the summers are hot. High wind velocities are common most of the year in the western portion of this sub-basin.

The annual rainfall averages 21 inches in the headwaters area and increases gradually to 27 inches at the mouth of the North Fork and to 37 inches further downstream to the confluence with the Washita River. The major portion of the rain falls in the late spring and summer with highest intensity of precipitation in the early spring.

Runoff varies generally as the rainfall. In the upper portion of the watershed stream flows are erratic and even intermittent above the mouth of the Little Wichita River. High temperatures, high evaporation and absorption account for most of the runoff in the upper basin area. Runoff increases progressively in the area below the Little Wichita River. Recorded values of average, maximum and minimum flows at gaging stations along the streams are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
Prairie Dog Town Fork--Canyon, Tex.......	—	11	12	6,650	0
Red River--Terral, Okla..................	22,280	9	—	197,000	43
Red River--Gainesville, Tex..............	29,460	9	—	168,000	48
Red River--Colbert, Okla.................	38,330	24	5,543	201,000	12
Salt Fork--Mangum, Tex...................	1,390	10	99	—	0
North Fork--Headrick, Okla...............	4,360	11	415	27,400	0
Wichita River--Wichita Falls, Tex........	3,105	10	354	50,000	6
Washita River--Durwood, Tex..............	7,310	19	1,712	91,300	17

Economic Development

Population.--The 1950 population of the Upper Red River Sub-Basin is approximately 560,000, about 10 percent of which reside in the high plains area. The remainder live in the rolling prairie area of Oklahoma and Texas with approximately 50 percent residing in Texas and 40 percent in Oklahoma. The largest city in the Upper Red River Sub-Basin is Wichita Falls (65,000) which is the industrial center of the region. Other principal population and trading centers are: Lawton - 34,527, Ardmore - 17,831, Duncan - 15,260, Altus - 9,548, Frederick - 5,449, Mangum - 4,257, and Sayre - 3,356, all in Oklahoma; and Denison - 17,444, Vernon - 12,684, Childress - 7,585, Hereford - 4,808, Quanah - 4,594, Wellington - 3,669, Henrietta - 2,820, Canyon - 4,349, Paducah - 2,940 and Clarendon - 2,572 in Texas.

Industry and Land Use.--Agriculture and livestock raising are important occupations in the sub-basin. Dry farming is practiced in the western portion of the sub-basin with wheat being the principal crop produced. Considerable acreage is also irrigated from ground water sources in the Panhandle district. Numerous truck farms in the Hereford, Tex. area are highly productive of potatoes and lettuce particularly. More diversified farming is practiced in the eastern portion of the sub-basin; cotton, corn, alfalfa, grains, dairy products, vegetables, and poultry are principal products. Grazing is carried out extensively on the high plains portion of the watershed.

Extensive petroleum and gas fields are located in this region and form the basis for industries associated with these resources. Wichita Falls, Ardmore, and Lawton are centers of petroleum processing. Food processing, textiles, meat packing, cement, and wood products manufacturing are carried out in the sub-basin area.

Future agricultural development depends upon soil and water conservation practices.

Use of Water Resources

Public water supplies in the sub-basin area are taken both from surface and ground water sources. Surface supplies are often inadequate because of erratic stream flows. Underground water is available in large quantities but in some areas contains a high concentration of fluorides. Both surface and ground waters are excessively hard from contact with natural mineral deposits and softening is essential in many instances. In the eastern portion of the sub-basin, ground waters are apt to have very high mineral contents which make them undesirable for general use.

There are 19 communities in the sub-basin which use surface water supplies to serve about 117,000 persons and 81 communities obtain their public water supplies from underground sources to serve about 115,000 persons.

Industrial water supplies for the large oil refining operations in the sub-basin are taken from surface sources; other industries use well supplies mainly. The use of ground water, for irrigation especially in the plains area, has increased considerably in the past few years. Excessive withdrawal from the underground sources has created a water supply problem because the water bearing strata are not being recharged satisfactorily.

There are few recreational areas in the sub-basin. Lakes Texoma, Lawtonka and Murray are the principal bodies of water available for recreational purposes.

Supplemental water is a need in the western portion of the sub-basin if ultimate development of farming is to be achieved in that area. Problems in the Upper Red River Sub-Basin are those of water conservation.

Pollution Data

Most communities in the sub-basin provide for treatment of their sewage to a greater or lesser degree before discharge to the streams. Low summer stream flows make sewage treatment necessary if nuisance conditions are to be avoided. Wastes from petroleum and gas production and processing complicate the pollution problem in some areas. Natural pollution caused by mineralization of the Upper Red River as it courses through the highly mineralized region is one of the major factors which limits its use for municipal and industrial supplies.

Summaries of available data on the sources and amounts of pollution originating in the Upper Red River Sub-Basin, together with existing treatment facilities and requirements, are presented in tables A_{15} through I_{15}.

Table A_{15} presents a summary of municipal pollution sources in the sub-basin. There are 71 sewered communities serving 272,300 persons which discharge their domestic wastes to the watercourses.

Table B_{15} summarizes the industrial waste pollution sources in the sub-basin. There are 99 such sources listed.

Table C_{15} summarizes the existing municipal waste treatment facilities in the sub-basin. Of the 71 sewered communities, five (seven percent) serving 17,400 persons provide no treatment; 32 (44 percent) serving 46,900 persons provide for primary treatment; and, 35 (49 percent) serving 208,000 provide for secondary treatment before discharging their wastes into the sub-basin streams.

Table D_{15} summarizes the existing industrial waste treatment facilities found in the sub-basin. These data are not complete as to type of industry.

Table E_{15} presents the adequacy of existing waste treatment facilities in the sub-basin. Of the 68 municipal waste treatment facilities 44 (65 percent) are inadequate as to capacity and 39 (57 percent) are unsatisfactory as to operation. No data are available for industrial plants.

Table F_{15} summarizes the pollution abatement progress made in the sub-basin during the period 1946 through 1949. No progress is indicated.

Table G_{15} summarizes the requirements for municipal and industrial waste treatment facilities in the Upper Red River Sub-Basin. New plants are required by five communities serving 17,400 persons; additions are required by 29 communities serving 143,100 persons and replacement of existing facilities is required by 20 communities serving 35,400 persons. No data are available for industrial plants.

Table H_{15} shows the status of pollution abatement projects in the sub-basin as of July

1, 1950. Three municipalities had plans for projects under preparation and three had treatment facilities under construction. No data are available regarding the status of industrial projects.

Table I_{15} shows the project list of municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Upper Red River Sub-Basin (Above Denison, Tex.) will be approximately $3,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

Table A_{15}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	7	57,200	16,300
Having population data available (Data on pollution load to watercourse incomplete or not available)	64	215,000	—
Total	71	272,300	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the many and varied kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table B_{15}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	[1]4	Undetermined
Producing inorganic wastes	3	—
Producing wastes of undetermined type	95	Undetermined
Total	[2]99	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes three sources also listed as producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

Table C_{15}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities* [1]	Plants	
Primary	32	32	46,900
Secondary	35	36	208,000
No treatment	5	—	17,400

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] One municipality has three plants, a primary and two secondary plants.

Table D_{15}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	3	—	—	3
Leather and leather products....................	1	0	1	0
Primary metal industries...	1	0	1	0
Railroad repair shop.......	1	1	0	0
Miscellaneous..............	93	—	—	93
Total.................	99	1	2	96

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{15}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	68	24	44	0	28	39	1
Industrial	11	—	—	1	—	—	1

Table F_{15}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	0	—	do	—
1949	0	—	do	—

Table G_{15}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	5	17,400	—
Enlargement or additions to existing plant	[1]29	143,100	—
Replace existing plant	20	35,400	—
No project required	18	76,100	—
Undetermined	1	300	99

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes 5 plants where existing units are of satisfactory capacity, but which require additional units to provide a higher degree of treatment.

Table H_{15}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	21	—
Abatement ordered	—	—
Plans under preparation	3	—
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	3	—
Status undetermined	28	99

Table I_{13}. Project list—municipalities and industries requiring improvements for [illegible]ement of pollution,* July 1, 1950

Name	Population served	Project requirements**	Remarks
OKLAHOMA			
Municipalities:			
Apache	900	E-A	—
Ardmore	15,700	E-A	—
Blair	400	E-A	—
Comanche	1,300	R	—
Davidson	400	E-A	—
Duncan	10,000	E-A	—
Eldorado	800	E-A	—
Elk City	4,500	E-A	—
Erick	1,200	E-A	—
Fletcher	740	E-A	—
Grandfield	900	R	—
Granite	800	E-A	—
Healdon	1,800	NP	—
Hollis	2,200	E-A	—
Hobart	5,000	E-A	—
Lone Wolf	600	E-A	—
Mangum	3,300	NP	—
Marietta	1,500	R	—
Ringling	800	R	—
Rocky	300	Und.	—
Ryan	1,000	NP	—
Sentinel	900	R	—
Synder	1,200	E-A	—
State Reformatory (Granite)	540	E-A	—
Temple	1,200	R	—
Tipton	1,500	E-A	—
Walters	2,000	NP	—
Waurika	2,400	E-A	—
Wilson	1,400	E-A	—
Industries:			
3 oil production industry	—	3 Und.	—
TEXAS			
Municipalities:			
Archer City	1,900	E-A	—
Burkburnett	4,500	R	—
Chillicothe	1,400	E-A	—
Clarendon	2,400	E-A	—
Claude	760	E-A	—
Crowell	1,800	E-A	—
Dimmitt	940	E-A	—
Electra	5,600	R	—
Estelline	600	E-A	—
Groom	470	R	—
Iowa Park	2,000	NP	Construction initiated or completed
LeFors	810	R	—
McLean	1,500	R	—
Matador	1,400	R	—
Memphis	3,400	E-A	—
Pampa	16,500	E-A	—
Quitague	760	E-A	—
Saint Jo	1,000	R	—
Shamrock	3,100	R	Construction initiated or completed

See footnotes at end of table

Table I$_{13}$. Project list--municipalities and industries requiring improvements for abatement of pollution,* July 1, 1950--Continued

Name	Population served	Project requirements**	Remarks
TEXAS -Continued			
Silverton	680	R	—
Turkey	930	R	—
Vernon	9,300	NP	—
Wellington	4,000	R	—
Wheeler	850	R	—
Whitesboro	2,000	R	—
Wichita Falls	62,500	E-A	Construction initiated or completed
Industries:			
1 primary metal industries	—	1 Und.	—
1 railroad repair shop	—	1 Und.	—
1 rendering plant	—	1 Und.	—
93 miscellaneous industries	—	93 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant

LOWER RED RIVER SUB-BASIN
(Below Denison, Texas)

Description

Geography.--The Lower Red River Sub-Basin includes all of that portion of the Red River drainage area from Denison, Tex. to the Mississippi River. The stream is approximately 760 miles in length and the drainage basin covers an area of approximately 27,500 square miles, of which 9,450 are in Texas, 8,150 are in Oklahoma, 5,400 are in Louisiana and 4,500 are in Arkansas. Eastward from Denison, Tex. the stream flows in a general easterly direction forming the boundary between Texas and Oklahoma and Texas and Arkansas. Shortly afterwards it turns sharply southward and flows south into Louisiana to beyond Shreveport where it again turns eastward and flows in a southeasterly direction to Alexandria, La. and to its junction with the Mississippi River at the southwest boundary point between Louisiana and Mississippi. The river below Alexandria, La. is known as the "backwater region" and extends from Alexandria to the river mouth approximately 120 miles distant. This is a low swampy timbered area.

Principal tributaries below the Washita River at Denison are: Blue, Boggy, Kiamichi, Little, Sulphur, Cypress, Bayou Dorcheat, and Ouachita Rivers.

Topography and Geology.--Through eastern Oklahoma the river plain is broad and is particularly suited to farming. Stream slopes average about one foot per mile. As the stream approaches Louisiana the country becomes a rolling plain which is heavily wooded with pine in the uplands and hardwoods in the bottom. The river channel becomes well defined and widens to 1,500 feet or more. Stream slopes are reduced to 0.5 foot per mile or less. The "backwater" region below Alexandria drains considerable swamp lands which are heavily timbered. There is little cultivation in this area and large areas are inundated during high water. The low water channel however, is well defined and relatively stable.

Climate and Hydrologic Features.--The climate of the sub-basin is humid with annual average precipitation ranging from about 38 inches at Denison, Tex. to 55 inches or more at the mouth of the Red River. The mean annual temperature is about 65°F. The January mean is 46°F. and the July mean is 82°F.

Low water flows range from 85 cubic feet per second at Denison to 720 cubic feet per second at Garland City. Flood flows at Denison have exceeded 450,000 cubic feet per second and at Shreveport 250,000 cubic feet per second. Recorded average, maximum and minimum flows at various gaging stations in the sub-basin are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
Red River--Colbert, Okla.	38,330	24	5,543	201,000	12
Red River--Garland, Ark.	51,500	20	18,930	327,000	400
Red River--Shreveport, La.	59,300	19	26,050	303,000	46
Red River--Alexandria, La.	65,900	19	33,380	233,000	1,480
Blue River--Blue, Okla.	471	9	—	34,400	0
Kiamichi River--Belzoni, Okla.	1,420	17	1,773	71,400	0
Little River--Horatio, Okla.	2,690	16	3,951	120,000	1
Sulphur River--Darden, Tex.	2,754	24	2,379	157,000	0
Cypress Creek--Jefferson, Tex.	848	23	667	57,100	0
Bayou Dorcheat--Minden, La.	1,090	12	1,255	21,600	0
Ouachita River--Monroe, La.	15,400	--	—	100,000	—

Economic Development

Population.--The 1950 population of the sub-basin area is approximately 1,077,000. The principal population, trade and manufacturing centers are: Shreveport - 125,506, Alexandria - 34,685, Minden - 9,776, and Natchitoches - 9,548, in Louisiana; Denison - 17,444, Paris - 21,636, Sherman - 20,073, Sulphur Springs - 8,994, and Mt. Pleasant - 6,348, in Texas; Texarkana - 40,490, in Texas and Arkansas; Hope - 8,602, Magnolia -

6,908 and Nashville - 3,528, in Arkansas; and Durant - 10,521, Hugo - 5,950, and Idabel - 4,621, in Oklahoma.

Industry and Land Use.--Agriculture is the predominate economic activity of the area. Cotton is the principal crop produced followed by corn, hay, grain, fruit, nuts, and vegetables. Hogs, mules, horses, and cattle are the livestock raised in this area.

Oil is an important natural resource found in this sub-basin. The principal fields are the Talco in Texas; the Fitto and Jessie in Oklahoma; and the Rodessa in Texas, Arkansas, and Louisiana. Petroleum refining and oil well equipment manufacture and principal industrial activities in Shreveport. Natural gas fields are also found near Shreveport.

The growing iron industry in the vicinity of Daingerfield, Tex., is particularly important to the economy of the Southwest. There are large numbers of cotton gins and oil presses located in the sub-basin. Other industries of importance are lumbering and wood products manufacturing, food products, meat packing, textiles, and chemicals.

There is much swamp land below Alexandria and some drainage has been accomplished.

Use of Water Resources

There are 33 communities in the sub-basin which utilize surface waters for their sources of public supplies to serve about 304,000 persons. Ground water sources are used by 115 communities to serve about 255,000 persons. Comparatively little information is available regarding the ground water resources of the sub-basin, however, rural water supply has not been a serious problem in the past except in some parts in Texas and Oklahoma.

Water supplies for the larger industries, including the iron industry near Daingerfield, Tex., and several oil refineries, are obtained principally from streams and other surface sources.

Water areas for recreational use are generally lacking. Caddo Lake on Cypress Creek and Oxbow Lakes along the lower river are utilized for this purpose.

The major water problem in the Lower Red River Sub-Basin is that of flood control.

Pollution Data

Stream pollution of a local nature in the sub-basin results from inadequate sewage and industrial wastes disposal practices. Pollution of surface waters affects their use for water supplies in some areas. Pollution of both surface and ground waters results from discharge of wastes from oil fields or from oil processing plants.

Summaries of the available data on the sources and amounts of pollution originating in the Lower Red River Sub-Basin, together with the existing treatment facilities and requirements, are presented in tables A_{16} through I_{16}.

Table A_{16} summarizes the sources of pollution from municipalities in the sub-basin. There are 67 sewered communities serving a population of 515,100 which discharge domestic wastes into the watercourses.

Table B_{16} presents a summary of sources of industrial pollution in the sub-basin. The data are not complete although 23 sources of industrial pollution are known--mostly oil fields.

Table C_{16} summarizes existing municipal waste treatment facilities. Of the 67 sewered communities in the sub-basin, 10 (15 percent) serving a population of 209,400 provide no treatment; 22 (33 percent) serving 45,000 persons provide for primary treatment; and 35 (52 percent) serving 206,700 persons provide for secondary treatment before discharging their wastes into the basin streams.

Table D_{16} summarizes existing industrial waste treatment facilities. Complete data on industry for the sub-basin as a whole are lacking but five are known to have treatment facilities.

Table E_{16} summarizes the adequacy of existing waste treatment facilities. Of the 61 municipal treatment facilities, 36 (59 percent) are inadequate as to capacity. The adequacy of the known industrial waste treatment facilities is undetermined.

Table F_{16} shows the progress in pollution abatement during the period 1946 through 1949. Two municipal treatment plants to serve about 10,000 persons were placed in operation during the period.

Table G_{16} lists the requirements for municipal and industrial waste treatment plants in this sub-basin. One new plant is required to serve 28,000 persons; additions are needed by 26 communities serving 63,400 persons and replacements are required by ten communities serving 128,100 persons. Twenty-nine municipalities serving 287,500 persons either have adequate treatment facilities or do not require plants for pollution abatement. Of the 23 industrial sources of pollution listed, seven need new treatment plants, four need enlargements or additions, and 10 require no projects. The need for two sources is undetermined.

Table H_{16} shows the status of pollution abatement projects as of July 1, 1950. One community has plans in preparation, one has final plans approved, and five have plants under construction. No industrial data are available.

Table I_{16} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Lower Red River Sub-Basin (Below Denison, Tex.) will be approximately $4,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_{16}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	11	27,000	10,800
Having population data available (Data on pollution load to watercourse incomplete or not available)	56	488,100	—
Total	67	515,100	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{16}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged into watercourse (in terms of equivalent number of people)
Producing organic wastes	1	120,000
Producing organic wastes	[1]15	Undetermined
Producing inorganic wastes	[1]15	—
Producing wastes of undetermined type	7	Undetermined
Total	[2]23	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Represents fifteen sources listed as producing both organic and inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus,[1].

Table C_{16}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants**	
Primary	22	23	45,000
Secondary	35	38	206,700
No treatment	10	--	209,400

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**One municipality has two primary plants and three municipalities each have two secondary plants.

Table D_{14}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry....	14	2	10	2
Paper and allied products..	1	1	0	0
Miscellaneous.............	8	2	1	5
Total.................	23	5	11	7

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{14}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	61	23	36	2	18	41	2
Industrial	5	—	—	5	—	—	5

Table F_{14}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	1	8,800	do	—
1949	1	1,000	do	—

Table G_{16}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	1	20,000	7
Enlargement or additions to existing plant	26	63,400	[1]4
Replace existing plant	10	128,100	—
No project required	29	287,500	[2]10
Undetermined	5	16,100	2

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*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] These 4 waste treatment plants, although shown in table E_{16} as having undetermined capacity, are known to require enlargement or additions.

[2] Includes six industries with undetermined waste treatment facilities which are classified as having no project requirements since the disposal of their wastes is considered satisfactory at the present time.

Table H_{16}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	1	—
Final plans approved	1	—
Construction awaiting financing	—	—
Under construction	5	—
Status undetermined	35	13

Table I_{16}. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
ARKANSAS			
Municipalities:			
Ashdown	2,300	E-A	—
DeQueen #1	2,500	E-A	—
#2	1,000	E-A	—
Lewisville	1,100	Und.	—
Magnolia #1	4,000	NP	—
#2	4,000	NP	—
Stamps	2,000	E-A	—
Waldo	1,000	E-A	—
Industries:			
None reported	—	—	—
LOUISIANA			
Municipalities:			
Jonesboro	4,000	R	—
Marksville	1,500	R	—
Plain Dealing	1,000	E-A	—
Industries:			
1 paper and allied products	[1]120,000	1 E-A	—
1 chemical and allied products	—	1 NP	—
1 miscellaneous	—	1 Und.	—
6 oil production industry	[2]84,600	6 NP	—
1 do	[2]200	1 Und.	—
1 do	—	1 E-A	—
2 do	[2]13,300	2 E-A	—
OKLAHOMA			
Municipalities:			
Antlers	3,200	E-A	—
Broken Bow	2,300	E-A	—
Coalgate	2,100	R	—
Pittsburg	500	E-A	—
Stringtown	600	E-A	—
Industries:			
None reported	—	—	—
TEXAS			
Municipalities:			
Atlanta	3,000	E-A	—
Bogata	1,500	E-A	—
Bonham	8,000	E-A	—
Clarksville	5,000	Und.	—
Commerce	6,500	E-A	—
Cooper	3,000	R	(3)
Daingerfield	1,500	E-A	(3)
DeKalb	1,500	E-A	—
Denison	20,000	NP	—
Deport	1,500	E-A	—
Honey Grove	3,500	R	—
Hooks	3,000	E-A	—
Hughes Springs	1,000	E-A	—
Jefferson	3,000	Und.	—
Ladonia	1,500	E-A	—
Linden	1,500	E-A	—
Mount Vernon	2,000	E-A	—
New Boston	3,500	Und.	(3)
Paris	30,000	R	—
Pittsburg	3,500	R	—

See footnotes at end of table

Table I_{16}. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served	Project requirements**	Remarks
TEXAS--Continued			
Roxton	1,000	E-A	—
Sulphur Springs	10,000	E-A	—
Talco	1,000	R	—
Texarkana	[4]75,000	R	(3)
Whitewright	2,000	E-A	—
Wolfe City	1,500	E-A	—
Industries:			
None reported	—	—	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.

[1] Population equivalent.

[2] Bbl./day waste discharged.

[3] Construction has been initiated or completed.

[4] Design population.

OUACHITA RIVER SUB-BASIN

Description

Geography.--The Ouachita River, one of the principal tributaries of the Red River, arises in the Ouachita Mountains in west-central Arkansas above Mena, Ark. and flows in a general easterly direction to Hot Springs, Ark. where it turns south and flows through Arkansas and Louisiana to its junction with the Red River about 35 miles above the confluence of the Red and the Mississippi rivers. The drainage basin is about 300 miles long and about 150 miles wide at its widest point. It embraces about 22,400 square miles of which 13,200 square miles are in Arkansas and the remainder in Louisiana. About 3,500 square miles of the drainage area are in the Ouachita Mountains. Principal tributaries are: Caddo River, Little Missouri River, Smackover Creek, Moro Creek, and Saline River in Arkansas; Bayou Bartholmew, Corney Creek, Bayou La Fourche and Tensas River in Louisiana.

Topography and Geology.--The Ouachita Mountains in the headwaters area consist of a series of narrow valleys and long ridges with elevations varying from 500 to 2,000 feet above sea level. The upper 158 miles of the Ouachita River drains these mountains by means of numerous short tributaries with a trellis-like pattern. Stream slopes are steep, averaging 12 feet per mile in this area. After leaving the mountains the stream enters the gentle sloping coastal plains which have an average altitude of about 250 feet. Stream slopes average about 3 feet per mile in this area. In Louisiana, the stream flows through the alluvial deposits of the Mississippi River valley at an elevation of about 100 to 150 feet.

Climate and Hydrologic Features.--The average annual temperature in the sub-basin is about 65°F., ranging from 46°F. in January to 82°F in July. The average annual precipitation is about 50 inches being heaviest in the winter months.

Runoff in the mountainous section is heavy and results in frequent floods. During dry weather, stream flow dwindles to small proportions. This results in a wide variation in stream flows with maximum peaks being in the neighborhood of 3,000 to 4,000 times the recorded minimums. Average, maximum and minimum flows at gaging stations in the sub-basin are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flows (c.f.s.)		
			Average	Maximum	Minimum
Ouachita River--Mountain Pine, Ark.	1,100	11	1,797	123,000	11
Ouachita River--Malvern, Ark.	1,570	20	2,368	140,000	40
Ouachita River--Monroe, La.	15,400	54	—	100,000	12
Little Missouri River--Murfreesboro, Ark.	380	13	627	120,000	3
Saline River--Rye, Ark.	2,040	10	2,660	47,600	8
Bayou La Forche--Crew Lake, La.	—	9	—	16,900	1
Tensas River--Tendal, La.	—	9	—	3,050	4

Economic Development

Population.--The 1950 population in the sub-basin area is approximately 741,500. The principal population, manufacturing and commercial centers are: Hot Springs - 29,298, El Dorado - 23,047, Camden - 11,341, Malvern - 8,015, Arkadelphia - 6,796 and Benton - 6,263 in Arkansas; and Monroe - 38,375, West Monroe - 10,286, Bastrop - 12,775, Ruston - 10,346, Tallulah - 7,775, and Homer - 4,756 in Louisiana.

Industry and Land Use.--Outside of the rich alluvial bottom lands, soils of the area are generally thin and poor. Principal crop is cotton. Overgrazing and cultivation of hillside lands have resulted in extensive erosion and soil deterioration.

Large bauxite deposits are mined in Pulaski and Saline Counties, Arkansas, for aluminum production and for utilization in the production of abrasives and chemicals. Petroleum is produced in the oil fields in southwestern Arkansas. Manufacturing developments are principally those associated with processing of lumber, bauxite ores, petroleum, and cotton. Paper is manufactured in the sub-basin from lumber processing wastes and from low grade timber.

Use of Water Resources

Public water supplies in the coastal plains area are principally derived from ground water sources. The quality of ground water is often poor, although quantities are ample except in the mountains and fringe area. Most of the river towns below Malvern, Ark., take their supplies from the stream. During periods of low flows the quality of the stream waters deteriorates greatly.

There are 12 communities in the sub-basin which utilize surface waters for their sources of public supplies to serve about 115,000 persons; 78 communities, serving about 168,000 persons, obtain their public supplies from ground water sources.

Surface water supplies are used by the minerals industries in the vicinity of Bauxite, Ark. Ground water supplies, however, are used to a greater extent by paper mills, chemical plants, textile mills, and wood products plants dispersed throughout the Arkansas portion of the sub-basin.

Water areas for recreational purposes are available in the Ouachita National Forest and additional areas are planned in both Arkansas and Louisiana.

The major water problems in this sub-basin are those of flood control and conservation of flood flows for better stream regulation during low flow periods.

Pollution Data

The discharge of raw sewage or primary treatment plant effluents is general practice in the sub-basin. The pollution problems are complicated by the discharge of wastes from oil fields and from paper mills into the streams.

Summaries of all available data on the sources and amounts of pollution originating in the Ouachita River Sub-Basin, together with existing treatment facilities and requirements, are presented in tables A_{17} through I_{17}.

Table A_{17} summarizes the sources of municipal pollution in the sub-basin. There are 46 sewered communities serving 207,700 persons discharging wastes into the watercourses.

Table B_{17} summarizes the known sources of industrial wastes pollution in the sub-basin. There are 12 such sources listed.

Table C_{17} is a summary of existing municipal treatment facilities. Of the 46 sewered communities, 12 (26 percent) serving 78,400 persons provide no treatment; 28 (61 percent) serving 74,000 provide for primary treatment; and 8 (3 percent) serving 55,300 persons provide for secondary treatment before discharging their wastes into the sub-basin watercourses.

Table D_{17} summarizes existing treatment facilities for industrial wastes in the sub-basin. There are eight treatment plants utilized by industry.

Table E_{17} summarizes the adequacy of existing treatment facilities in the sub-basin. Of the 40 municipal treatment plants, 28 (70 percent) are inadequate as to capacity, and 29 (73 percent) are inadequate as to operation. The status of five of the eight industrial plants is undetermined.

Table F_{17} shows the progress in pollution abatement during the period 1946 through 1949. During this period one municipal treatment plant to serve 11,800 persons was placed in operation. No industrial data are available.

Table G_{17} lists the requirements for municipal and industrial waste treatment facilities in

Table A_{17}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	—	—	—
Having population data available (Data on pollution load to watercourse incomplete or not available)	46	207,700	—
Total	46	207,700	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

the Ouachita Sub-Basin. New plants are required in six municipalities to serve 52,300 persons; additions are needed to 23 municipal plants serving 68,900 persons and replacements of five municipal plants serving 22,400 are required. Waste treatment plant requirements have not been determined for 7 industries.

Table H_{17} summarizes the status of pollution abatement projects in the sub-basin as of July 1, 1950. Status of most of the municipal and industrial projects for this sub-basin is undetermined.

Table I_{17} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Ouachita River Sub-Basin will be approximately $3,500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determing the type and magnitude of waste treatment facilities for the varied kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table B_{17}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	1	49,000
Producing organic wastes	[1]7	Undetermined
Producing inorganic wastes	5	—
Producing wastes of undetermined type	3	Undetermined
Total	[2]12	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes four sources also listed as producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1]

Table C_{17}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants**	
Primary	28	31	74,000
Secondary	8	9	55,300
No treatment	12	—	78,400

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Three municipalities each have two primary plants, one municipality has two secondary plants, and two municipalities have primary treatment for part of sewage and no treatment for part.

Table D_{17}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Paper and allied products.	4	4	0	0
Oil production industry...	3	1	2	0
Primary metal industries..	1	—	—	1
Chemical and allied products................	1	—	—	1
Miscellaneous.............	3	3	0	0
Total.................	12	8	2	2

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{17}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	40	7	28	5	6	29	5
Industrial	8	3	—	5	3	—	5

Table F_{17}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	0	—	do	—
1949	1	11,800	do	—

Table G_{17}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	6	52,300	—
Enlargement or additions to existing plant	23	68,900	—
Replace existing plant	5	22,400	—
No project required	11	45,700	5
Undetermined	7	18,400	7

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_{17}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	—	—
Final plans approved	5	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	36	7

Table I_{17}. Project list—municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
ARKANSAS			
Municipalities:			
Arkadelphia	4,000	NP	—
Bauxite	800	E-A	—
Bearden	800	E-A	—
Benton	3,500	Und.	—
Benton State Hospital	2,000	E-A	—
Camden-A	2,500	R	—
Camden-B	5,000	NP	—
Crossett	4,900	E-A	—
Dermott	2,500	NP	—
Dumas	1,600	E-A	—
El Dorado	15,000	R	—
Lion Chemical Plant	1,500[1]	E-A	—
Eudora	1,400	E-A	—
Fordyce#1	1,000	E-A	—
#2	2,000	E-A	—
Glenwood	500	E-A	—
Gurdon	1,500	E-A	—
Hamburg	1,500	E-A	—
Hot Springs#1	30,000	E-A	—
#2	7,000	E-A	—
Huttig	1,400	NP	—
Lake Village	900	E-A	—
McGehee	3,800	R	—
Mena	2,000	E-A	—
Monticello	2,000	Und.	—
#2	2,000	Und.	—
PW Camp	300	Und.	—
Mt. Pine	500	R	—
Pine Bluff#5	600	Und.	—
#1 Jefferson County	10,000	Und.	—
Grider Air Field	—	Und.	—
Prescott	3,000	E-A	—
Rison	800	E-A	—
Sheridan	1,000	E-A	—
Smackover	2,500	NP	—
Star City	900	E-A	—
Stephens	800	E-A	—
Warren#1	1,500	E-A	—
#2	1,500	E-A	—
Wilmot	625	R	—
ARKANSAS			
Industries:			
1 paper and allied products	—	1 Und.	—
1 chemical and allied products	—	1 Und.	—
1 primary metal industries	—	1 Und.	—

See footnotes at end of table

Table I_{17}. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served	Project requirements**	Remarks
LOUISIANA			
Municipalities:			
Monroe......................	36,900	NP	—
Industries:			
3 oil production industry...	—	3 Und.	—
1 paper and allied products..	[1]49,000	1 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A =Enlargement or addition to existing plant.
R =Replacement of existing plant.
Und.=Undetermined.
NP =New plant.

[1] Population equivalent.

LOWER MISSISSIPPI RIVER BASIN
(Big Black River Sub-Basin)

Description

Geography.--The Big Black River rises in the uplands of Webster and Choctaw Counties in central Mississippi and flows in a general southwesterly direction along these uplands to its junction with the Mississippi River below Vicksburg. The stream has a length of nearly 180 miles and a total drainage area of about 5,000 square miles. The drainage subbasin is long and narrow, being 30 miles at its greatest width. There are no long tributaries, lateral drainage is carried by short channels.

Topography and Geology.--The upper half of the river drains a severely eroded uplands region. The lower portion of the river enters the Mississippi delta area. The channel in this region is quite tortuous. The sub-basin at one time was heavily forested.

Climate and Hydrologic Features.--The climate is warm and the annual average temperature is about 65° F. Average rainfall is about 55 inches per year over the sub-basin and is fairly well distributed throughout the year. Runoff is somewhat erratic and floods are not infrequent because of rapid runoff in the uplands. Average, maximum and minimum stream flows at two gaging stations in the subbasin are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average*	Maximum	Minimum
Pickins, Miss.	1,460	9	2,601	37,900	27
Bovina, Miss.	2,810	9	4,522	46,000	72

*1947 average.

Economic Development

Population.--The 1950 population in the sub-basin area, which is mostly rural, is approximately 283,000. Canton, Miss. with a population of 7,063 is the largest community in this sub-basin. Other population centers are: Crystal Springs--3,676, Winona--3,432, and Port Gibson--2,911.

Industry and Land Use.--Farming is the predominant occupation with cotton and corn being the leading crops. Some lumbering is carried on locally.

Soil erosion is a major problem in the upland area.

Use of Water Resources

All of the public water supplies in the subbasin are derived from ground water resources. Twenty-one communities use this source of supply to serve about 25,300 persons.

Flood control is the major water problem in this sub-basin. It is difficult to achieve because the sub-basin is too narrow for the utilization of levees and impoundments would cover most of the lands to be protected. Erosion control and reforestation of the uplands should help reduce flood conditions.

Pollution Data

Pollution problems in this sub-basin are largely local. Summaries of the available data on sources and amounts of pollution originating in the Big Black River watershed, together with existing treatment facilities and requirements are presented in tables A_{18} through I_{18}.

Table A_{18} summarizes the sources of municipal pollution in the sub-basin. There are 15 sewered communities serving a population of 23,400 which discharge domestic wastes to the watercourses.

Table B_{18} summarizes industrial pollution sources in the sub-basin. There are three known sources.

Table C_{18} is a summary of existing municipal waste treatment facilities. Of the 15 sewered communities, five serving 13,000 persons provide no treatment, and 10 serving 10,400 persons provide for primary treatment of their wastes before discharge to the streams.

Table D_{18} summarizes existing industrial waste treatment facilities. None of the industries listed have treatment facilities.

Table E_{18} is a summary of the adequacy of existing waste treatment plants. Of the 10 municipal plants, eight are unsatisfactory as to capacity and six are unsatisfactory as to operation. No data are available for industrial facilities.

Table F_{18} summarizes progress in pollution abatement for the period 1946 through 1949. No progress is indicated.

Table G_{18} lists the requirements for municipal and industrial waste treatment plants. New plants are required by four communities to serve 12,000 persons; additions are needed for one plant serving 2,000 persons and seven municipal plants serving 7,300 persons need replacements. No data are available for the requirements of industry.

Table H_{18} shows no data available on the status of treatment works projects as of July 1, 1950.

Table I_{18} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Lower Mississippi River Basin (Big Black River Sub-Basin) will be approximately $1,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_{18}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	15	23,400	20,400
Having population data available (Data on pollution load to watercourse incomplete or not available)	—	—	—
Total	15	23,400	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{18}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	3	Undetermined
Producing inorganic wastes	—	—
Producing wastes of undetermined type	—	—
Total	3	—

*Industries having separate outlets and discharging wastes directly into watercourse.

Table C_{18}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	10	10	10,400
Secondary	0	0	0
No treatment	5	—	13,000

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D_{18}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	1	0	1	0
Textile mill products......	1	0	1	0
Lumber and wood products (except furniture).......	1	0	1	0
Total................	3	0	3	0

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{18}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	10	2	8	0	4	6	0
Industrial	0	--	--	--	--	--	--

Table F_{18}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	No data	--
1947	0	--	do	--
1948	0	--	do	--
1949	0	--	do	--

Table G_{18}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	4	12,000	—
Enlargement or additions to existing plant	1	2,000	—
Replace existing plant	7	7,300	—
No project required	3	2,100	—
Undetermined	0	0	3

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in these needs.

Table H_{18} Status of treatment works project to abate pollution, July 1, 1950*

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	—	—
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	12	3

Table I_{18}. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements **	Remarks
MISSISSIPPI			
Municipalities:			
Bolton......................	500	R	—
Canton......................	5,000	NP	—
Clinton.....................	2,000	E-A	—
Crystal Springs.............	2,000	R	—
Durant......................	2,000	NP	—
Edwards.....................	900	R	—
Eupora......................	1,500	R	—
Flora.......................	500	R	—
Port Gibson.................	2,000	NP	—
Raymond.....................	1,200	R	—
Utica.......................	700	R	—
Winona......................	3,000	NP	—
Industries:			
1 food and kindred products.	—	1 Und.	—
1 textile mill products.....	—	1 Und.	—
1 lumber and wood products (except furniture)......	—	1 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.

ATCHAFALAYA RIVER SUB-BASIN

Description

Geography.--This sub-basin lies entirely within the State of Louisiana. The principal streams which drain the area into the Gulf of Mexico are the Mermentau, Vermilion and Atchafalaya Rivers and their connecting and interconnecting drainage channels. The area drained by these streams covers about 10,600 square miles and is bounded on the north by the Red River Divide; on the south by the Gulf of Mexico; on the west by the Calcasieu River Divide; and on the east by the east levee of the Atchafalaya River. The Atchafalaya River serves as a flood relief channel for the Red and Mississippi Rivers systems.

Topography and Geology.--The streams rise below an escarpment along the northern boundary of the sub-basin and flow generally southward across the gently sloping gulf plain to the Gulf of Mexico. Stream slopes are flat, and the flows in their lower reaches are ill-defined and are affected by tides or by heavy runoff flows. Interconnecting channels are common in the lower reaches. The plains give way to rather extensive salt marsh areas ranging up to 20 or more miles in width along the Gulf. The geological characteristics of the coastal plain is that of subsidence.

Climate and Hydrologic Features.--The climate is humid and is characterized by relatively high rainfall and mild winter temperatures. The average annual rainfall is about 60 inches. Average annual temperatures are about 69°F., with January averages of about 46°F. and August averages of near 83°F. Rainfall is rather evenly divided throughout the year, but less rain falls in the summer and fall than during the remainder of the year.

Discharge measurements on the streams are somewhat meager. Discharge measurements from published records available for gaging stations on streams in this sub-basin are tabulated below:

Gaging station	Years of record	Stream flow (c.f.s.)		
		Average	Maximum	Minimum
Atchafalaya River--Krotz Springs, La..	13	153,000	575,000	17,400
Bayou Cocodrie--Clearwater, La....	12	444	1,800*	55
Bayou Teche--Gulf of Mexico..........	--	--	2,270*	35

*Year 1947 only

Economic Development

Population.--The 1950 population of the sub-basin area is approximately 541,000. The principal population and marketing centers are: Lafayette - 33,465, New Iberia - 16,460, Opelousas - 11,600, Crowley - 12,704, Jennings - 9,735, Abbeville - 9,318, and Eunice - 8,186.

Industry and Land Use.--Agriculture is the major economic activity in this area with cotton, rice and sugar cane being the principal crops. The central portion of the sub-basin, principally on the Vermilion and Mermentau Rivers is devoted to rice culture where considerable surface water is available for irrigation of this crop.

There are a large number of oil fields located throughout the sub-basin. Sugar mills are located at frequent intervals along the Bayou Teche between Opelousas and Morgan City. Other industries in the sub-basin are food processing, cotton seed processing and meat packing.

Use of Water Resources

Public water supplies are obtained principally from ground water sources which are generally of ample quantity and fair quality except in the areas near the Gulf where salt water intrusions are encountered.

There are only four communities serving about 10,000 persons in the sub-basin which utilize surface waters as their sources of public supplies and 49 communities serving about 147,000 persons, obtain their supplies from ground water sources.

Considerable quantities of surface waters from the Mermentau and Vermilion Rivers are utilized for the irrigation of rice.

All of the larger streams are navigable in their lower reaches and are used for transportation and by fishing boats.

A serious problem encountered in the eastern portion of this sub-basin is that of flood protection. The Atchafalaya River is utilized as a relief channel for flood waters of the Mississippi River by way of the Morganza floodway and as an outlet for flood waters from the Red River. There are extensive levee systems along the Atchafalaya as protection against inundation of the farm lands along the flood plain.

Drainage of low lying lands is important for the control of malaria and for successful agriculture.

Pollution Data

The disposal of oil field brine wastes to prevent the pollution of surface waters used for the irrigation of rice is an important problem in this sub-basin. Considerable effort has been directed toward the control of these wastes with the result that disposal methods are practiced which employ either impounding or reinjection of the brine to the sub-strata.

The wastes from the processing of sugar cane are also of importance during the harvesting campaign in the late fall of each year. These wastes are high in organic content and produce local nuisance conditions in the streams during the operating season.

Summaries of the sources and amounts of pollution originating in this sub-basin, together with the existing treatment facilities and requirements, are presented in tables A_{19} through I_{19}.

Table A_{19} summarizes the municipal sources of pollution in this sub-basin. There are 16 municipalities having sewer systems serving an estimated 106,900 persons which discharge domestic wastes to the watercourses.

Table B_{19} is a summary of available data on sources of industrial wastes pollution. Of the 43 sources listed, 30 contribute organic wastes and the remaining 13 contribute both organic and inorganic wastes.

Table C_{19} summarizes the existing municipal sewage treatment facilities. Of the 16 sewered communities in this sub-basin, four do not provide any treatment for an estimated population of 14,800. One provides primary treatment for 4,600 persons and the remaining 11 communities provide for secondary treatment for an estimated population of 87,500.

Table D_{19} summarizes the existing industrial waste treatment facilities in the sub-basin. Treatment facilities are supplied for oil production wastes only as determined from present data.

Table E_{19} summarizes the adequacy of existing waste treatment facilities. Of the 12 municipal treatment plants, 4 (33 percent) are inadequate as to capacity and three (25 percent) are inadequate as to operation. Similar data are not available for the 11 industrial waste treatment facilities.

Table F_{19} shows the progress in pollution abatement during the period 1946 through 1949. Data available indicate that no plants for abatement of pollution have been completed.

Table G_{19} summarizes the requirements for industrial and municipal waste treatment plants for this sub-basin. Four plants serving an estimated 29,100 persons require additions or enlargements. All of the known industrial waste treatment plants have undetermined requirements.

Table H_{19} shows the status of treatment works projects to abate pollution as of July 1, 1950. The status of municipal and industrial projects is undetermined.

Table I_{19} shows the project list of municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Atchafalaya River Sub-Basin will be approximately $500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_{19}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	--	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	16	106,900	--
Total	16	106,900	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{19}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	[1]43	Undetermined
Producing inorganic wastes	13	--
Producing wastes of undetermined type	0	--
Total	[2]43	--

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes thirteen sources also listed as producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

Table C_{19}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	1	1	4,600
Secondary	11	11	87,500
No treatment	4	--	14,800

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

Table D_{19}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry...	13	11	--	2
Food and kindred products.	30	--	11	19
Total.................	43	11	11	21

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{19}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	12	8	4	0	9	3	0
Industrial	11	--	--	11	--	--	11

Table F_{19}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	0	—	do	—
1949	0	—	do	—

Table G_{19}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	0	—	—
Enlargement or additions to existing plant	4	29,100	—
Replace existing plant	0	—	—
No project required	12	77,800	—
Undetermined	0	—	43

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_{19}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	—	—
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	4	43

Table I_{19}. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
LOUISIANA			
Municipalities:			
Abbeville....................	7,000	E-A	—
Franklin.....................	2,500	E-A	—
Jeanerette..................	4,600	E-A	—
Lafayette....................	15,000	E-A	—
Industries:			
13 oil production industry..	—	13 Und.	—
30 food and kindred products	—	30 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
Und. = Undetermined.

CALCASIEU RIVER SUB-BASIN

Description

Geography. --The Calcasieu River arises in Vernon Parish near the western boundary of Louisiana. It flows in a southerly direction to the Gulf of Mexico, entering the Gulf about 30 miles east of Sabine Pass. The stream is about 215 miles long and embraces a drainage area of about 4,100 square miles. The drainage sub-basin lies wholly within the State of Louisiana. The river enters Lake Charles about 45 miles above its mouth. Below Lake Charles the river becomes a tidal estuary. The stream enters Calcasieu Lake about 25 miles above its mouth. This lake is about 18 miles long. The outlet from Calcasieu Lake to the Gulf is known as Calcasieu Pass. Principal tributaries are Whiskey Chitto Creek, Barnes Creek and West Fork.

Topography and Geology--The stream is navigable for 97 miles above its mouth. The source of the Calcasieu is in the Kisotchie Escarpment which forms the most prominent relief feature in the State of Louisiana with heights of 350 to 400 feet above mean sea level. The Gulf coast in the vicinity of the Calcasieu River shows evidence of alluvial filling and subsidence. Deltic clays underlie the entire prairie section of Louisiana at shallow depths. These deposits dip southward and extend for many miles into the Gulf of Mexico. Low sandy ridges rising from the marshes furnish evidence of former gulf margins inland from the present coast line which had been pushed southward by alluviation. The present cycle is one of subsidence and encroachment by the Gulf, with practically no alluviation in progress.

The area above Lake Charles was once heavily timbered but has now been cut over. The area about Lake Charles is suitable for agriculture and farther east considerable acreage is devoted to rice culture. The coastal marsh extends to the south of Lake Charles.

Climate and Hydrologic Features. --The climate is warm and humid. Average annual temperatures are about 68°F. Average rainfall in the Calcasieu Sub-Basin is about 60 inches per year and is well distributed; however, less rain falls in the summer and fall than at other seasons. Stream flow is low during the summer and fall because of less runoff and high evaporation and transpiration on the watershed during this period. Recorded average, maximum and minimum stream flows at various gaging stations are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
LOUISIANA					
Calcasieu River--Oberlin..	753	11	1,337	34,700	42
Kinder.....	1,700	11	3,024	68,000	200
Whiskey Chitto Creek--Oberlin..	510	8	--	35,000	102

Economic Development

Population. --The 1950 population of the sub-basin area is approximately 152,600. Principal population centers are Lake Charles - 53,820, Oakdale - 7,000, and DeRidder - 3,750.

Industry and Land Use. --The major industrial development in this sub-basin is related to petroleum production. There are about 20 oil fields in the vicinity of Lake Charles, mostly in Calcasieu and Cameron Parishes.

Above Lake Charles, farming is a major occupation, with cotton, rice, corn, and peanuts the principal crops. Much rice is grown in the area east of Lake Charles.

Industrial activities are those associated with the products of the area. Petroleum processing, cotton gins, rice mills, paper mills, and food processing are some of the major activities. Salt production also is a large and prosperous industry of the region.

Muskrat trapping and farming is carried out extensively in the marshes south of Lake Charles.

Use of Water Resources

Large volumes of water from the Calcasieu River are used for rice cultivation. It is estimated that 3.5 acre feet of water is required to mature each acre of rice field.

Public water supplies are obtained solely from ground water sources. There are 11 such supplies in the sub-basin serving about 49,000 persons.

in the Lake Charles area, considerable water from surface sources is used for industrial purposes, principally by oil refineries and paper mills.

Navigation is important in the Calcasieu River below Lake Charles. Above Lake Charles the stream is navigable to shallow draft vessels. The port at Lake Charles is accessible to ocean going ships and is a major factor in the economic development of the adjacent region.

Pollution Data

There is a considerable industrial waste pollution problem in the Lake Charles area. Some treatment is afforded by the impoundment of certain of the wastes produced. Oil field brines in this area are mostly disposed of by means of subsurface injection methods because of their detrimental effects upon the rice growing areas.

Summaries of available data on sources and amounts of pollution originating in the sub-basin, together with existing treatment facilities and future requirements, are presented in tables A_{20} through I_{20}.

Table A_{20} shows that there are six municipalities in this sub-basin having sewer systems which serve 70,900 persons.

Table B_{20} summarizes the industrial waste pollution sources in the sub-basin. Data were available for 11 industries.

Table C_{20} is a summary of existing municipal waste treatment facilities. Of the six sewered communities, one (population - 7,000) provides no treatment for its wastes before discharge to the Stream. Camp Polk with an undetermined population provides two secondary treatment plants for its sewage.

Table D_{20} summarizes existing waste treatment facilities provided by industry. Of the 11 plants listed, only three provide for some type of waste treatment.

Table E_{20} is a summary of the adequacy of existing waste treatment facilities in the sub-basin. Five of the six municipal treatment plants are adequate as to both capacity and operation. No data are available on the adequacy of industrial waste treatment facilities.

Table F_{20} shows progress in pollution abatement during the period 1946 through 1949. No municipal treatment plants were built and there are no data regarding industrial plants.

Table G_{20} summarizes requirements for municipal and industrial waste treatment plants in the sub-basin. One new municipal plant and one replacement are required to serve 10,800 persons. Of the 11 industrial plants upon which data are available, one new waste treatment plant is required, two need enlarging, three require no projects and the requirements for five plants are undetermined.

Table H_{20} shows the data as of July 1, 1950 on the status of treatment works projects to abate pollution. The status of municipal or industrial projects is undetermined.

Table I_{20} shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Calcasieu River Sub-Basin will be approximately $500,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the many and varied kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table A_{20}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	—	—	—
Having population data available (Data on pollution load to watercourse incomplete or not available)	6	70,900	—
Total	6	70,900	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{20}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	1	440,000
Producing organic wastes	[1]8	Undetermined
Producing inorganic wastes	5	—
Producing wastes of undetermined type	1	Undetermined
Total	[2]11	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes four sources also listed as producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

Table C_{20}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	1	1	3,800
Secondary	4	[1]5	60,100
No treatment	1	—	7,000

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] One municipality has two secondary plants.

Table D_{20}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Oil production industry...	2	—	1	1
Paper and allied products.	1	—	—	1
Lumber and wood products (except furniture)......	1	—	—	1
Chemical and allied products................	3	1	—	2
Products of petroleum and coal....................	2	1	1	0
Miscellaneous............	2	1	1	0
Total................	11	3	3	5

*Industries having separate outlets and discharging wastes directly into watercourse.

Table E_{20}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	6	5	1	0	5	1	0
Industrial	3	—	—	3	—	—	3

Table F_{20}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	0	—	do	—
1949	0	—	do	—

Table G_{20}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	1	7,000	1
Enlargement or additions to existing plant	0	—	2
Replace existing plant	1	3,800	—
No project required	5	60,100	[1]3
Undetermined	0	—	5

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Two industries with waste treatment facilities of undetermined capacity are classified as requiring no project, since the disposal of their wastes is considered satisfactory at the present time.

Table H_{20}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	—	—
Final plans approved	—	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	2	8

Table I$_{20}$. Project list--municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements**	Remarks
LOUISIANA			
Municipalities:			
DeQuincy....................	3,800	R	—
Oakdale.....................	7,000	NP	—
Industries:			
1 chemical and allied products..............	7,000 g.p.m.[1]	1 E-A	—
1 oil production industry..	3,600 Bbl/day[1]	1 Und.	—
1 lumber and wood products (except furniture).....	—	1 Und.	—
1 paper and allied products.	—	1 NP	—
2 chemical and allied products..................	—	2 Und.	—
1 products of pertoleum and coal....................	10,000 Bbl/day[1]	1 Und.	—
1 products of petroleum and coal....................	440,000[2]	1 E-A	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A = Enlargement or addition to existing plant.
R = Replacement of existing plant.
Und. = Undetermined.
NP = New plant.

[1] Amount of waste discharged.

[2] Population equivalent.

LOWER MISSISSIPPI RIVER BASIN
(Natchez, Miss. to Gulf Sub-Basin)

Description

Geography.--This sub-basin includes the east bank drainage of the Mississippi River in the States of Mississippi and Louisiana from Natchez, Miss. to the Gulf. The drainage area includes about 11,000 square miles of the southwest corner of Mississippi and of southeastern Louisiana including the Lake Pontchartrain area. An area of about 1,600 square miles on the west bank of the Mississippi between the river and the east Atchafalaya Levee also is included in this sub-basin. Besides the immediate drainage of the Mississippi River, the area includes the drainage areas of the Amite, Tickfaw, Natalbany, Tangipahoa and Tchefuncte Rivers which drain into Lakes Maurepas and Pontchartrain. Bayou Lafourche is the principal stream in the area to the west of the Mississippi River.

Topography and Geology.--The drainage area lies within the delta deposits of the Mississippi River Basin. Stream slopes are flat and drainage in the lower reaches of the streams is not well defined and depends upon tidal action and flood runoff. The area below New Orleans is largely swamp and salt marshes. The geologic era is one of subsidence rather than of delta building.

Climate and Hydrologic Features.--The climate of this region is humid and mild. Rainfall averages above 60 inches per year which is somewhat uniformly distributed throughout the year. Minimum rainfall occurs in the late summer and fall. Average temperature for the area is about 68° F. Average temperatures for January are in excess of 40° F. and those for August range about 80° F.

The flow in the Mississippi River at New Orleans varies from 150,000 cubic feet per second to over 1,000,000 cubic feet per second. At Natchez, peak flows of nearly 3,000,000 cubic feet per second have been recorded.

Recorded stream flow for other streams in this sub-basin are tabulated below:

Gaging station	Drainage area (square miles)	Years of record	Stream flow (c.f.s.)		
			Average	Maximum	Minimum
LOUISIANA					
Amite River--Denham Springs................	1,330	9	--	40,200	279
Tickfaw River--Holden......................	271	7	--	9,680	90
Natalbany River--Baptist...................	80	4	--	4,960	4
Tangepahoa River--Robert...................	646	9	--	35,500	264
Tchefuncte River--Folsom...................	96	3	--	9,780	37

Economic Development

Population.--The 1950 population of the sub-basin area is approximately 1,212,000. The principal population, manufacturing and marketing centers are New Orleans--567,257, Baton Rouge--123,957, Hammond--8,015, Jackson--6,767, and Palquemine--5,737, all in Louisiana and Natchez--22,678 in Mississippi. Baton Rouge is a rapidly growing industrial center which has had a population increase of 257 percent in the past ten years.

Industry and Land Use.--The major land use in the region is for agricultural purposes. Principal crops are cotton, corn, sugar cane, and truck farming produce. Livestock raising is associated with the agricultural activities.

Oil production and processing is a major industrial activity in this sub-basin with sulphur production, chemicals, and allied industries becoming of increasing importance. A large alumina industry is being established in the vicinity of Baton Rouge to process alumina from imported ores. Other manufacturing includes processing of sugar and other foods, cottonseed, lumber, and wood products.

Fishing is an important industry along the Gulf. Many kinds of seafood including shellfish are obtained in the area. The processing of menhaden for their oils and other products is carried out along the Gulf.

Fur trapping and processing is a major industry in the swamp and marsh areas. The lands were once heavily forested and lumbering is still an extensive activity in certain areas.

Use of Water Resources

Both surface and ground water sources are plentiful in the sub-basin. Artesian waters are available in quantity in the Pontchartrain area but are being depleted gradually by poor conservation practices.

Twenty-four communities, including the city of New Orleans, utilize surface sources for their public water supplies and serve a total of 645,000 persons. Ground water sources are used by 47 communities to serve about 207,000 persons.

The Tangipahoa and Tickfaw Rivers are used extensively for fishing. Commercial fishing is carried out in this area and in the bordering Gulf waters.

Navigation is important in this sub-basin. Large ships can navigate the Mississippi Rive to Baton Rouge, a distance of approximately 200 miles.

The conservation of wildlife is an important consideration in this sub-basin. Wild fowl and bird refuge areas are available in the more inaccessible marsh and swamp area and the preservation of fur-bearing animals in the marsh areas is desirable.

Flood control is extremely important in certain areas. Flood relief spillways have been constructed from the Mississippi River to Lake Pontchartrain to relieve flood heights at New Orleans and along the lower Mississippi River.

Pollution Data

Stream pollution is not serious except in a few local areas where industrial wastes cause problems. Industrial wastes from Baton Rouge may affect the New Orleans water supply if the concentration of wastes becomes high enough. For the most part stream flows are more than adequate to afford disposal of wastes by dilution. Waste treatment may be required in some areas for the protection of fish. The discharge of untreated sewage from New Orleans prevents use of certain shellfish growing areas below the city. Where sewage is discharged to drainage canals or to small runs, treatment is required to prevent nuisance conditions.

Summaries of the sources and amounts of pollution originating in this sub-basin, together with the existing treatment facilities and requirements are presented in tables A_{21} through I_{21}.

Table A_{21} is a summary of the municipal sources of pollution. There are 30 sewered communities in this sub-basin serving an estimated 862,700 persons, 582,400 of which are in New Orleans.

Table B_{21} summarizes the sources of industrial waste pollution in this sub-basin. There are 58 known sources listed.

Table A_{21}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	5	35,200	24,900
Having population data available (Data on pollution load to watercourse incomplete or not available)	25	827,500	—
Total	30	862,700	—

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table C_{21} summarizes the existing municipal treatment facilities. Of the 30 sewered communities, 11 (37 percent) serving a total of 752,800 persons have no treatment facilities, five (17 percent) provide for primary treatment, and 14 (46 percent) serving 101,500 persons have secondary treatment facilities.

Table D_{21} summarizes the existing industrial waste treatment facilities. Of the 58 industries listed, treatment is provided by only four and facilities are undetermined in five instances. The data on industry are not complete.

Table E_{21} presents a summary of the adequacy of existing treatment facilities in this sub-basin. Of the 20 municipal treatment plants, seven (35 percent) are inadequate as to capacity and 10 (50 percent) are inadequate as to operation. Of the four known industrial waste treatment plants, two are satisfactory and the status of the other two is undetermined.

Table F_{21} is a summary of the progress of pollution abatement in this sub-basin during the period 1946 through 1949. No progress is shown.

Table G_{21} summarizes the requirements for municipal and industrial waste treatment plants. Municipal requirements are for two new plants to serve 6,000 persons, four plants to be enlarged to serve 21,500 persons and four plants serving 16,000 persons to be replaced. No data are available on the status of industrial waste treatment requirements.

Table H_{21} summarizes the status of treatment works projects for pollution abatement as of July 1, 1950. Three municipalities have plans approved for construction. The remainder have undetermined status. No industrial data are available.

Table B_{21}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	—	—
Producing organic wastes	[1]47	Undetermined
Producing inorganic wastes	8	—
Producing wastes of undetermined type	8	Undetermined
Total	[2]58	—

*Industries having separate outlets and discharging wastes directly to watercourse.

[1] Includes five sources also listed as producing inorganic wastes.

[2] Total adjusted to correct for duplication noted in footnote marked thus, [1].

Table I $_{21}$ shows the project list for municipalities and industries requiring improvements for abatement of pollution.

It is estimated that the initial cost of needed municipal waste treatment facilities in the Lower Mississippi River Basin (Natchez, Miss., to Gulf Sub-Basin) will be approximately $1,000,000. This estimate is based on average construction costs considered reasonable for this area and includes treatment projects involving new plants, replacements of obsolete and inadequate plants, and improvements or additions to existing plants. Considered in the estimate is the cost for providing treatment of industrial wastes discharged into municipal sewers.

The lack of data regarding other sources of industrial pollution and the complexities involved in determining the type and magnitude of waste treatment facilities for the many and varied kinds of industries precludes an estimate of cost for providing needed industrial waste treatment facilities in the sub-basin.

Table C_{21}. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	5	5	8,400
Secondary	14	[1]15	101,500
No treatment	11	—	752,800

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers; and sanitary sewage wastes discharged by industry directly into watercourse.

[1] One municipality has two secondary plants.

Table D_{21}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	39	—	38	1
Oil production industry....	3	1	1	1
Lumber and wood products (except furniture).......	4	1	2	1
Products of petroleum and coal.....................	3	1	1	1
Chemical and allied products.................	3	0	3	0
Miscellaneous.............	6	1	4	1
Total.................	58	4	49	5

*Industries having seperate outlets and discharging wastes directly into watercourse.

Table E_{21}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	20	12	7	1	9	10	1
Industrial	4	2	—	2	2	—	2

Table F_{21}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	—	No data	—
1947	0	—	do	—
1948	0	—	do	—
1949	0	—	do	—

Table G_{21}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	2	6,000	—
Enlargement or additions to existing plant	[1]4	21,500	—
Replace existing plant	4	16,000	—
No project required	20	818,800	4
Undetermined	1	450	54

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

[1] Includes 1 plant where existing units are of satisfactory capacity, but which require additional units to provide a higher degree of treatment.

Table H_{21}. Status of treatment works project to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	—	—
Abatement ordered	—	—
Plans under preparation	—	—
Final plans approved	3	—
Construction awaiting financing	—	—
Under construction	—	—
Status undetermined	8	54

Table I_{21}. Project list—municipalities and industries requiring improvements for abatement of pollution* July 1, 1950

Name	Population served	Project requirements**	Remarks
LOUISIANA			
Municipalities:			
Amite	1,950	R	—
Covington	3,500	E-A	—
East Louisiana State Hospital (Jackson)	4,500	NP	—
Gramercy	450	Und.	—
Hammond#1	8,000	E-A	Under construction
#2			
Houma	10,000	R	—
Independence	2,000	R	—
Slidell	2,000	R	—
Industries:			
35 food and kindred products	—	35 Und.	—
3 oil production industry	—	3 Und.	—
9 chemical and allied products	—	9 Und.	—
3 products of petroleum and coal	—	3 Und.	—
1 miscellaneous	—	1 Und.	—
MISSISSIPPI			
Municipalities:			
McComb	10,000	E-A	—
Magnolia	1,500	NP	—
Industries:			
1 lumber and wood products (except furniture)	—	1 Und.	—
1 chemical and allied products	—	1 Und.	—
1 rubber products	—	1 Und.	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**E-A =Enlargement or addition to existing plant.
R =Replacement of existing plant.
Und.=Undetermined.
NP =New plant.

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